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## DRAFT BASELINE HUMAN HEALTH RISK ASSESSMENT SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

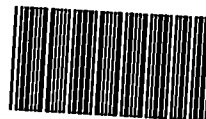
### **Prepared for**

McGinnes Industrial Maintenance Corporation  
International Paper Company  
U.S. Environmental Protection Agency, Region 6

### **Prepared by**

Integral Consulting Inc.  
411 1st Avenue S, Suite 550  
Seattle, Washington 98104

**December 2012**



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## LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
ABS <sub>d</sub>	dermal absorption factor for soil/sediment
AhR	aryl hydrocarbon receptor
ATSDR	Agency for Toxic Substances and Disease Registry
BEHP	bis(2-ethylhexyl)phthalate
BHHRA	Baseline Human Health Risk Assessment
CSM	conceptual site model
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
COI	chemical of interest
COPC	chemical of potential concern
COPC <sub>H</sub>	chemical of potential concern for human health
CSF	cancer slope factor
CTE	central tendency exposure
CWA	Coastal Water Authority
DLC	dioxin-like compound
DMP	Data Management Plan
DQO	Data Quality Objective
EAM	Exposure Assessment Memorandum
EPC	exposure point concentration
FCA	fish collection area
HEAST	USEPA's Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
I-10	Interstate Highway 10
IPC	International Paper Company
IRIS	Integrated Risk Information System
JECFA	Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives
LADD	lifetime average daily dose

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LOAEL	lowest-observed-adverse-effects level
MIMC	McGinnes Industrial Maintenance Corporation
NOAEL	no-observed-adverse-effects level
NTP	National Toxicology Program
OEHHA	Office of Environmental Health Hazard Assessment
PCB	polychlorinated biphenyl
POD	point of departure
PRA	probabilistic risk assessment
PSCR	Preliminary Site Characterization Report
RAGS	Risk Assessment Guidance for Superfund
RBA	relative bioavailability adjustment
REP	relative effect potencies
RfD	reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RME	reasonable maximum exposure
RsD	risk-specific dose
SAB	Science Advisory Board
SALG	Seafood and Aquatic Life Group
SAP	sampling and analysis plan
Site	San Jacinto River Waste Pits site in Harris County, Texas
TCDD	tetrachlorodibenzo- <i>p</i> -dioxin
TCRA	time-critical removal action
TDI	tolerable daily intake
TDSHS	Texas Department of State Health Services
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TEQ <sub>DF</sub>	toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors
TEQ <sub>P</sub>	toxicity equivalent for polychlorinated biphenyls calculated using mammalian toxicity equivalency factors
TESM	Toxicological and Epidemiological Studies Memorandum
TMDL	total maximum daily load

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UAO	Unilateral Administrative Order
UCL	upper confidence limit on the mean
USEPA	U.S. Environmental Protection Agency
WOE	weight-of-evidence

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## 1 INTRODUCTION

This draft Baseline Human Health Risk Assessment (BHHRA) was prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC; collectively referred to as the Respondents) in fulfillment of the Unilateral Administrative Order (UAO), Docket No. 06-03-10, issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009 (USEPA 2009b), for the San Jacinto River Waste Pits site in Harris County, Texas (the Site)<sup>1</sup>. The UAO directs the Respondents to perform a Remedial Investigation and Feasibility Study (RI/FS) which includes a BHHRA as part of the Remedial Investigation (RI). This document fulfills the UAO requirement for the BHHRA and also builds on the conceptual site models (CSMs) described in the Preliminary Site Characterization Report (PSCR) (Integral and Anchor QEA, 2012b) and the Exposure Assessment Memorandum (EAM) (Integral 2012a) for the area included within USEPA's Preliminary Site Perimeter<sup>2</sup>—the impoundments north of Interstate Highway 10 (I-10) and aquatic environment (Figure 1-1) and for the southern impoundment (Figure 1-2).

USEPA's Preliminary Site Perimeter (Figure 1-3), as presented in the UAO and discussed more fully in the RI Report and in Section 2.1 below, includes several impoundments used in the mid-1960s for the disposal of paper mill wastes and in-water and upland areas. The UAO made reference only to two impoundments located to the north of I-10. USEPA has subsequently required an investigation of an impoundment located on the peninsula to the south of I-10, citing historical documents that indicate possible waste disposal activities in that area<sup>3</sup>. In light of this, and in parallel with the organization of the RI Report, this BHHRA addresses these two impoundment areas separately, as the "northern impoundments" or "impoundments north of I-10" and as the "southern impoundment." Where appropriate, investigations and analyses that were performed separately in these two areas of study are differentiated in the text using references to the "area north of I-10" and

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<sup>1</sup> References to "the Site" in this document are intended as reference to the formally designated SJRWP Superfund site and not to a geographical area.

<sup>2</sup> For the purposes of this document, the term "USEPA's Preliminary Site Perimeter" refers to the area shown within the "preliminary perimeter" in Appendix B of the UAO.

<sup>3</sup> The Respondents have submitted letters to USEPA dated July 20, 2011, setting out their respective positions with regard to the inclusion of the "southern impoundment" as a part of the RI/FS under the UAO.

the “area of investigation on the peninsula south of I-10”. The distinction between these areas primarily applies to information on hypothetical terrestrial exposure scenarios that involve possible human contact with upland soil. For organizational purposes, exposures and risks from contact with aquatic media (i.e., sediment and tissue) are presented together with the discussion of potential exposures and risks for the area north of I-10.

### **1.1 Purpose**

USEPA guidance for conducting an RI/FS under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) requires that remedies at contaminated sites be protective of human health and the environment (USEPA 1988). Baseline risk assessments evaluate the potential threats to human health and to the environment posed by sites in the absence of any remedial action. Specifically, a BHHRA is an analysis of the potential adverse health effects for individuals who may be exposed to or may be reasonably anticipated to be exposed in the future to hazardous substances released from a site in the absence of any actions to control or mitigate those releases. The results of the BHHRA are used to help determine whether remedial action is needed, and to provide the basis for the evaluation of the effectiveness of any subsequent remedial action. Specifically, results of the BHHRA provide a point of reference for evaluating risks under the no-action alternative and for quantifying risk reduction that can be achieved by each of the other remedial alternatives considered in the feasibility study. Risk models in the BHHRA are based on hypothetical exposure scenarios under baseline conditions, and are not intended to and cannot be utilized to determine whether any actual exposures are occurring or may have occurred. Because they are based on hypothetical exposure constructs, they also cannot be used to identify any actual adverse health effects from any exposures.

A description of baseline conditions and an overview of key aspects of the approach employed for this BHHRA are provided below. Each of these aspects is described in greater detail in subsequent sections of this BHHRA.

### **1.2 Baseline Conditions**

For the area north of I-10 and aquatic environment, baseline specifically means environmental conditions that existed immediately prior to implementation of the time-

critical removal action (TCRA). For the area of investigation on the peninsula south of I-10, baseline refers to the current condition. Baseline conditions are characterized for the BHHRA using the baseline dataset, as discussed further in Section 3.1. TCRA construction was completed in 2011 and involved installation of fencing and warning signs in addition to construction of an armored cap over the northern impoundments. The TCRA and the manner in which it changed potential human exposures are discussed further in Section 2.1. There is no basis for assuming that baseline represents conditions that existed at any time earlier than immediately prior to the TCRA, or that baseline conditions would have continued to exist had the TCRA not been implemented.

### 1.3 Overview of Approach

The approaches and methodologies presented in this BHHRA are consistent with USEPA guidance for conducting human health risk assessments and with data quality objectives (DQOs) and related statements and information presented by the sediment, tissue, and soil sampling and analysis plans (SAPs) that were submitted to and approved by USEPA (Integral and Anchor QEA 2010; Integral 2010a,b, 2011b,c), and the RI/FS Work Plan (Anchor QEA and Integral 2010). USEPA guidance that was considered for this BHHRA included, but was not limited to:

- Risk Assessment Guidance for Superfund (RAGS) Volume I Part A (USEPA 1989)
- RAGS Volume I Part B—Development of Risk-Based Preliminary Remediation Goals (USEPA 1991a)
- RAGS Volume I Part C—Risk Evaluation of Remedial Alternatives (USEPA 1991b)
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (USEPA 1991c)
- Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA 1993)
- Soil Screening Guidance: User's Guide (USEPA 1996)
- Exposure Factors Handbook (USEPA 2011a)<sup>4</sup>

<sup>4</sup> The RI/FS Work Plan (Anchor QEA and Integral 2010) prescribed the use of USEPA's 1997 *Exposure Factors Handbook* (USEPA 1997a) and USEPA's 2008 *Child Specific Exposure Factors Handbook* (2008). Since the publication of the RI/FS WP, EPA has updated its *Exposure Factors Handbook* (USEPA 2011a), which was used for the BHHRA.

- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002c)
- RAGS Volume I Part E—Supplement Guidance for Dermal Risk Assessment (USEPA 2004)
- Texas Administrative Code sections containing exposure equations and parameters (TAC 350.74-75)

In line with the requirements in the UAO, an Exposure Assessment Memorandum (EAM) (Integral 2012a) and a Toxicological and Epidemiological Studies Memorandum (TESM) (Integral 2012b) were prepared and submitted to USEPA. These memoranda described the specific, hypothetical human use scenarios, exposure assumptions, and toxicological criteria to be used in this BHHRA. The final EAM and TESM are included as methodological appendices to this document (Appendix A and B, respectively).

Key aspects of the evaluation process for this BHHRA are summarized below, including identification of the chemicals of potential concern (COPCs), the hypothetical exposure scenarios evaluated, the types of potential health effects evaluated, the tiered approach used for selecting exposure scenarios for refined analyses, and the manner in which uncertainties in the risk assessment were addressed.

### **1.3.1 Chemicals of Potential Concern**

Chemicals of potential concern for human health (COPCHs) are selected in order to help focus a BHHRA on the chemicals that may drive human health risks.

The EAM and TESM presented COPCHs for the area north of I-10 and aquatic environment (Table 1-1). These COPCHs were identified according to steps described in the RI/FS Work Plan (Anchor QEA and Integral 2010) and the Sediment SAP (Integral and Anchor QEA 2010). Briefly, chemicals of interest (COIs) were identified as constituents that could have been associated with the paper mill waste deposited into the impoundments during the 1960s. COIs were further screened to identify COPCHs. This screen considered comparisons with risk-based screening values, bioaccumulation potential, and whether or not the COI was detected in sediments from within the impoundment area. The selection of COPCHs for

the area north of I-10 and aquatic environment is documented in Appendix C of the RI/FS Work Plan (Anchor QEA and Integral 2010) and in the COPC Technical Memorandum (Integral 2011a).

At the time the EAM and TESH were submitted, characterization of the soils in the area of investigation on the peninsula south of I-10 was ongoing; therefore, COPCHs for soils in this area were not presented in those documents. In May 2012, additional soil samples were collected from the area of investigation south of I-10 and analyzed for COIs. Data from the March 2011 Phase I soil sampling effort and the May 2012 Phase II investigation were screened to identify COPCHs for the area of investigation on the peninsula south of I-10 (Table 1-2). The methods and results of this screening are included as Appendix C to this document.

### **1.3.2 Human Exposure Scenarios Evaluated**

The BHHRA characterizes the potential for adverse health effects to hypothetical receptors who may have used the Site under baseline conditions. As a result of TCRA implementation in 2011, the baseline condition no longer exists in the area north of I-10 and aquatic environment. For this area, the potential for adverse health effects to hypothetical receptors under the conditions following the TCRA (i.e., termed as the post-TCRA condition throughout this BHHRA) is also characterized.

As presented in the EAM, exposure media of concern for the area north of I-10 and aquatic environment are sediments and soils that hypothetical receptors may have contacted and fish and shellfish that may have been consumed. For the area north of I-10 and aquatic environment, potential health effects are quantified in this BHHRA using hypothetical recreational fisher, subsistence fisher, and recreational visitor scenarios. The risk evaluation was completed for a series of different hypothetical scenarios for each of these receptor groups. These scenarios assumed that an individual could have been exposed to different areas of the area north of I-10 and aquatic environment and/or could have ingested different types of tissue. Other hypothetical receptor groups who are assumed to have less contact with media in the area north of I-10 and aquatic environment than these receptors are qualitatively discussed within the context of these quantified results. For the area of

investigation on the peninsula south of I-10, potential health effects were quantified for a hypothetical trespasser and worker.

### **1.3.3 Health Effects Evaluated**

For this BHHRA, three categories of potential health effects were characterized. These were defined consistent with USEPA guidance as follows:

- **Cancer risks**—Defined as the incremental probability that an individual will develop cancer during his or her lifetime because of assumed exposure to a COPC at a site. The term “incremental” reflects the fact that the calculated risk associated with a site-related exposure is in addition to the background risk of cancer experienced by all individuals in the course of daily life. These risks were calculated for all potentially carcinogenic COPCHs that are assumed to have a linear dose response and no threshold dose.
- **Noncancer hazards**—The potential for noncancer health effects to occur was evaluated by comparing the estimated average daily intake of a chemical over the duration of assumed exposure to a toxicity criterion derived for a similar exposure period to calculate a hazard quotient (HQ) for each exposure route and COPCH. HQs for multiple exposure routes evaluated for a single receptor group were summed to derive a COPCH-specific hazard index (HI) for the receptor. The HIs for compounds that cause toxicity at the same health endpoint were summed, resulting in a total HI for that receptor group. Unlike estimated cancer risks, the total HI is not a measure of probability, but instead is a measure of the likelihood and degree to which an adverse health effect might occur within the population evaluated (USEPA 1989).
- **Dioxin cancer hazard**—For some carcinogens a threshold (minimum) dose must be reached before a carcinogenic effect can occur. For these carcinogens, the potential for cancer to occur as a result of the assumed exposure is estimated using a hazard metric like that described for noncancer hazards above. The cancer hazard metric is used to evaluate dioxins and furans in this BHHRA. The use of this metric was established in the TESH, and is further discussed in Sections 5 and 6 below.

The manner in which each of these health effect metrics was interpreted is discussed in Section 5.

### **1.3.4 Tiered Approach for Risk Characterization**

In this BHHRA, a tiered approach was applied for the risk characterization. A diagram outlining the approach used is provided as Figure 1-4. The three health effect categories described above were first evaluated for each potential receptor group and scenario via a deterministic evaluation. When the deterministic evaluation indicated that one or more of the following threshold criteria were met, additional evaluations to further characterize and refine the potential risks and/or hazards were completed for that scenario:

- (1) The cumulative estimated exposure from all pathways resulted in an incremental cancer risk greater than one in 10,000 ( $>1 \times 10^{-4}$ ).
- (2) The cumulative estimated exposure from all pathways resulted in a total endpoint-specific noncancer HI  $>1$ .
- (3) The cumulative estimated exposure from all pathways resulted in a dioxin cancer HI  $>1$ .

For each scenario meeting one or more of these criteria, the refined analyses consists of three additional evaluations. These include 1) an analysis and comparison of background risks and/or hazards with the estimated deterministic risks and/or hazards for the area of study (i.e., either the area north of I-10 and aquatic environment or the area of investigation on the peninsula south of I-10), 2) an evaluation of post-TCRA risks and/or hazards, and 3) a probabilistic analysis of potential risks and/or hazards. Post-TCRA risks were only evaluated for scenarios and receptors considered by this BHHRA for the area north of I-10 and aquatic environment.

For the background evaluation, background risks and/or hazards for potential exposure routes included in the given scenario were calculated and compared to the deterministic risks and/or hazards for media being evaluated. This analysis allows for an evaluation of additional, incremental risk.

Risks and/or hazards for these potential exposure routes were also calculated for the post-TCRA condition. Post-TCRA risks and/or hazards were only calculated for dioxins and

furans.<sup>5</sup> As outlined in the EAM for the Site, and described further in Section 2.1, the TCRA included capping that provided a barrier to direct contact with sediments in the northern impoundments and fencing that limited access to certain areas within USEPA's Preliminary Site Perimeter, including the capped area and surroundings (Figure 1-5). This comparison of potential baseline and post-TCRA risks and/or hazards allows the risk reduction achieved by the TCRA to be quantified.

In addition to the background and post-TCRA comparisons, any scenario that resulted in deterministic risk estimates that exceed one or more of the risk threshold criteria described above was evaluated using a probabilistic risk assessment (PRA). As is more fully discussed in Section 5.2.3.3, PRA uses probability distributions to characterize variability or uncertainty in exposure and risk estimates (USEPA 2001), and ultimately offers more detailed insight into both the magnitude and the probability of any potential exposure and risk. The PRA was performed for those COPCHs that contribute  $\geq 5$  percent of the overall risk and/or hazard in the selected scenarios, under the rationale that COPCHs that contributed  $\geq 5$  percent to the pathway-specific hazard/risk associated with a specific medium are considered potential risk drivers. The term "risk driver," which is repeated throughout this BHHRA, refers to these specific chemicals. Potential risks associated with the area under study and background risks and/or hazards were evaluated as part of the PRA.

### **1.3.5 Characterization of Uncertainty**

There is uncertainty in the results of any risk assessment. USEPA (1989) guidance states the importance of presenting and discussing the uncertainties in the risk assessment in order to place the risk estimates in proper perspective. For this BHHRA, the sources of uncertainty and their overall impact on the risk results are discussed, with a focus on those uncertainties that impact the overall results to the greatest degree. Both quantitative and qualitative evaluations of uncertainty were completed, depending on the amount and type of information available.

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<sup>5</sup> As is further described in Section 5.2.3.2, data for all COPCHs in all media of interest for post-TCRA conditions are not available and therefore, dioxins and furans were used to provide a relative measure of hazard and/or risk. Dioxins and furans have been established as an indicator chemical for the RI. Use of an appropriately chosen indicator chemical focuses the remedial strategy and is consistent with USEPA (1988) guidance for conducting an RI/FS under CERCLA.

## **1.4 Document Organization**

This document is organized as follows:

- Section 2. Background
- Section 3. Hazard identification
- Section 4. Toxicity assessment
- Section 5. Exposure and risk characterization for the area north of I-10 and aquatic environment
- Section 6. Exposure and risk characterization for the area of investigation on the peninsula south of I-10
- Section 7. References.

It also includes the following appendices:

- Appendix A Exposure Assessment Memorandum
- Appendix B Toxicological and Epidemiological Studies Memorandum
- Appendix C Screening Analysis for the Area of Investigation on the Peninsula South of I-10
- Appendix D Supplemental Toxicological and Chemical-Specific Parameters
- Appendix E Exposure Point Concentrations for Baseline and Background Exposure Estimates
- Appendix F Post-TCRA Exposures and Risks for the Area North of I-10 and Aquatic Environment: Methods and Results
- Appendix G Exposure Assumptions for Probabilistic Assessment
- Appendix H Human Health Exposure and Risk Estimates for the Area North of I-10 and Aquatic Environment
- Appendix I Human Health Exposure and Risk Estimates for Background
- Appendix J Human Health Exposure and Risk Estimates for the Area of Investigation on the Peninsula South of I-10

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## **2 BACKGROUND**

This BHHRA draws on the findings of a number of studies and documents that have been submitted to and approved by USEPA (Integral 2012a,b; Anchor QEA and Integral 2010; Integral and Anchor QEA 2010; Integral 2010b, 2011a,b,c) and it provides a key component of the analyses required for the RI Report. This section briefly presents background information on the Site setting, population demographics, and receptor groups evaluated in this BHHRA.

### **2.1 Site Setting**

USEPA's Preliminary Site Perimeter includes several impoundments that were used in the mid-1960s for the disposal of paper mill wastes, and in-water and upland areas as depicted in Figure 1-3.

The northern impoundments consist of two impoundments, together occupying approximately 14 acres, and are located on a 20-acre parcel north of the I-10 Bridge on the western bank of the San Jacinto River. Historical documents and aerial photographs suggest that in the mid-1960s an additional impoundment (i.e., the southern impoundment) was constructed on a peninsula of land south of I-10 and may have been used for the disposal of paper mill waste. At various times, the southern impoundment area and other portions of the area south of I-10 may have been used for the disposal of other waste material. Figure 1-3 shows the area within USEPA's Preliminary Site Perimeter, as presented in the UAO, and notes the specific area for the soil investigation south of I-10.

Implementation of a TCRA to address soils and sediments associated with the impoundments north of I-10 was completed in 2011. Through the installation of geotextile and geomembrane underlayments and a granular cover, the TCRA stabilized the entire area within the 1966 perimeter of the impoundments north of I-10 (Figure 2-1). Fencing installed as part of the TCRA implementation limited access to the impoundments north of I-10, areas to the immediate west of these impoundments, and the eastern shore of the San Jacinto River immediately adjacent to I-10. The Coastal Water Authority (CWA) also installed fencing on the east side of the San Jacinto River channel, along the western side of a road that passes under the I-10 Bridge, limiting access to the shoreline in this area. The

placement of fences is shown in Figure 1-5. The condition that resulted from the TCRA and the additional fencing installed by the CWA collectively are described in this document as the “post-TCRA” condition.

## **2.2 Demographics**

The area within USEPA’s Preliminary Site Perimeter is located in Channelview, a suburb of Houston in Harris County, Texas. At the time of the 2010 census, the population of Harris County was 4,092,459, with 8.2 percent of the population under 5 years of age and 30.8 percent under the age of 20 years. Fifty-seven percent of the population was Caucasian, 19 percent African American, 6 percent Asian, with the remainder made up of individuals of another race or mixed race. Approximately 40 percent of individuals were Hispanic.<sup>6</sup> The median household income was \$51,000. Approximately 17 percent of individuals and 14 percent of families had incomes below the national poverty level for one year or longer during the period from 2005 to 2010 (USCB 2012).

In 2010, the population of Channelview was 38,289. The median age of 28 years was younger than that reported for Harris County. Roughly 10 percent of the population was under 5 years of age and 37.8 percent was under the age of 20 years. The racial makeup of Channelview was similar to Harris County; however, the percentage of Hispanics in Channelview was greater at approximately 60 percent (USCB 2012). The median household income and percentage of individuals and families with incomes below poverty level for one year or longer from 2005 to 2010 in Channelview were comparable to those reported for Harris County.

## **2.3 Conceptual Site Models**

USEPA defines a CSM for site investigation as a written description and a visual representation of the predicted relationship between a stressor and a potential receptor (USEPA 1998) and it describes the potential sources, release mechanisms, transport pathways, and environmental exposure media of chemicals to receptors. The CSM provides a

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<sup>6</sup> Hispanic origin can be viewed as the heritage, nationality group, lineage, or country of birth of the person or the person’s parents or ancestors before their arrival in the United States. People who identify their origin as Hispanic may be any race.

framework that facilitates application of the risk assessment process to the conditions and use of a site.

An exposure pathway links sources of COPCs to potential receptors and defines those links in terms of specific exposure routes. An exposure route is the physical way in which human receptors may come into contact with COPCs present in exposure media (i.e., ingestion, dermal absorption, inhalation). Under USEPA guidance, exposure pathways are considered potentially complete and significant if the potential exposure occurs frequently over an extended duration and/or the exposure medium represents a “significant” potential source of site-related COPCs to the receptor. Exposure pathways are considered potentially complete but “minor” if the exposure medium represents a relatively minor potential source of site-related exposure to a chemical, and/or potential for contact to the medium is limited. The relative importance of each pathway and route is relevant because pathways that are considered potentially complete and significant are those that provide the greatest risk reduction when addressed by remedial action.

Existing CSMs, developed in the RI/FS Work Plan (Anchor QEA and Integral 2010), refined in the PSCR (Integral and Anchor QEA 2012b), and presented in the EAM (Integral 2012a) describe the environment of the northern and impoundments and aquatic environment and the area of investigation south of I-10 and the manner in which humans may have been exposed to impacted media in those areas under baseline conditions. These CSMs are described below, with emphasis on the potentially complete and significant pathways and exposure routes.

### **2.3.1 Area North of I-10 and Aquatic Environment**

The CSM for the area north of I-10 and aquatic environment is shown in Figure 1-1. Figure 2-2 identifies the potential routes of human exposure in detail and indicates whether they are considered significant or minor. For this area, hypothetical recreational and subsistence fishers, recreational visitors, and trespassers were identified as groups that may have contact with impacted media under baseline conditions. These receptor groups are discussed below following a general discussion of the minor pathways.

Consistent with the Public Health Assessment for the Site (TDSHS 2012), potential inhalation of COPCHs in air and exposure via direct contact with surface water were defined as minor pathways for this risk assessment. Inhalation exposure via vapor inhalation is considered minor because none of the COPCHs identified are volatile compounds and, therefore, would not tend to volatilize into ambient air. While inhalation of particulates derived from the resuspension of surface soil may occur, this pathway generally contributes less than one percent of total estimated exposure when direct soil contact pathways (ingestion and dermal contact) are considered. This is demonstrated with standard exposure assumptions used for determining residential and industrial soil screening levels (USEPA 2012a). Exposure to COPCHs in surface water is also considered to be a minor pathway for this Site. This is because the primary COPCHs at this Site, dioxins and furans, are hydrophobic, are not soluble in water, and tend to be tightly bound to the organic carbon fraction of sediments<sup>7</sup>. It is possible that individuals could be exposed to COPCHs that adsorb to suspended sediment particles in the water column, but those exposures would be brief and minimal because the movement of the surface water will continually wash away the majority of the sediment particles that contact the skin, leaving little opportunity for absorption.

As described in the EAM (Integral 2012a) and the RI/FS Work Plan (Anchor QEA and Integral 2010), minor pathways were not evaluated quantitatively, but rather were addressed qualitatively. Specifically, information about the physical-chemical properties of the COPCHs defined as risk drivers were used to describe the likely extent of their presence in media for which exposures are considered minor. Evaluation of minor pathways also included a description of the likelihood, frequency, and intensity with which exposures via minor pathways and routes are anticipated to occur for each potential receptor.

#### 2.3.1.1 Fishers

Fishing activity within the waters surrounding USEPA's Preliminary Site Perimeter has been observed and fishers in this area have been reported to collect whatever they catch (Beauchamp 2010, Pers. Comm.). However, little information is available about the type and amount of fishing that occurs. The limited information that is available is based on observations of the area within USEPA's Preliminary Site Perimeter. Specifically, fishing is

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<sup>7</sup> Available at <http://www.epa.gov/ogwdw/pdfs/factsheets/soc/tech/dioxin.pdf>

reported to have been popular at the northern tip and along the northeast side of the area of the northern impoundments prior to implementation of the TCRA. People were observed to wade out in the water on the east side and fish and use crab cages in this area. Prior to implementation of the TCRA, fishing was reportedly also observed to the south of the northern impoundments area and under the I-10 Bridge, on both sides of the channel. Other points of fishing access within USEPA's Preliminary Site Perimeter include RV trailer parks on the east side of the river north of I-10 that provide access to the river, and a public access area at Meadowbrook Park to the west (Beauchamp 2010, Pers. Comm.).

Fishers may potentially be exposed to COPCHs via direct contact with sediments and soils, and by ingesting fish or shellfish that have been exposed to impacted media. They may also potentially be exposed to COPCHs through direct contact with surface water (ingestion and dermal contact) and through inhalation of COPCHs as particulates or vapors in air; however, exposures via these media and routes are considered to be minor (Figure 2-2).

#### 2.3.1.2 *Recreational Visitors*

Although the lands within USEPA's Preliminary Site Perimeter are largely privately owned, points of access were available to the public along and within this area under baseline conditions (i.e., immediately prior to the TCRA). Such access allowed for a variety of recreational activities other than fishing, including picnicking, walking, bird watching, wading, and boating. Shoreline use and wading within USEPA's Preliminary Site Perimeter were reportedly observed under baseline conditions (Beauchamp 2010, Pers. Comm.).

Recreational visitors could potentially be exposed via the same direct contact exposure routes as fishers (i.e., incidental ingestion of and dermal contact with soils and sediments). However, these individuals are not exposed via ingestion of fish or shellfish.

#### 2.3.1.3 *Trespasser*

Signs of trespassing have been reported in some areas within USEPA's Preliminary Site Perimeter, particularly under the I-10 Bridge. Although a trespasser could be exposed via the same pathways as the recreational visitor (i.e., direct contact pathways) and recreational fisher (i.e., ingestion of fish and shellfish), the trespasser exposure would likely be

intermittent and of a shorter term than the exposures being evaluated for either of those scenarios. Thus, for the area north of I-10, the estimated risks and hazards presented for the fishers and recreational visitors would overstate potential risks for trespassers. As discussed in the EAM, the hypothetical trespasser scenario was not evaluated quantitatively for the area north of I-10 and aquatic environment. A discussion of the exposure that would be anticipated for the trespasser relative to exposures calculated for the recreational visitor and recreational fisher is, however, included as part of the risk characterization for the area north of I-10 and aquatic environment.

### **2.3.2 Area of Investigation South of I-10**

The CSM for the area of investigation on the peninsula south of I-10, shown in Figures 1-2 and 2-3, describes the specific routes of potential exposure in detail. For this area, trespassers and commercial workers were identified as groups that may potentially come into contact with impacted media. These receptor groups are discussed below.

#### **2.3.2.1 Trespasser**

With signs of trespassing in areas along the western bank of the River within USEPA's Preliminary Site Perimeter, it is possible that trespassers might walk around or spend time in the area of investigation on the peninsula south of I-10. Because such activities might result in direct contact with surface soil, potentially complete exposure pathways for the trespasser are incidental ingestion and dermal contact with soil. Because fencing and active management and use of industrial properties south of I-10 make this area largely inaccessible, it is anticipated that the trespasser's exposure would be infrequent. Also it is likely that trespassing activities by any given individual would be limited to a relatively short time frame, i.e., no more than a few years.

#### **2.3.2.2 Commercial Worker**

Land use on the peninsula south of I-10 is commercial/industrial. Commercial workers, who perform maintenance or other work-related outdoor activities, might have potential direct contact with surface and shallow subsurface soil. Potentially complete exposure pathways for the commercial worker are incidental ingestion and dermal contact with surface and shallow subsurface soil.

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### **3 HAZARD IDENTIFICATION**

Hazard identification consists of a data evaluation step to define appropriate environmental data relevant to potential human exposures. This section presents an overview of the data that were used to evaluate potential risks to under the scenarios evaluated and the data treatment rules that were applied.

#### **3.1 Baseline Data**

Available data used in this BHHRA to evaluate potential exposures are summarized in Table 3-1 and discussed below. This section describes the datasets used to assess potential exposures for the area north of I-10 and aquatic environment and the area of investigation on the peninsula south of I-10 and background exposures, and is followed by a description of the data types that were used. The specific data that were used to evaluate each potential exposure pathway under each exposure scenario are described in the EAM (Appendix A) and Section 5 of this BHHRA in the context of the individual potential receptor groups evaluated.

##### **3.1.1 Datasets**

The RI/FS Work Plan (Anchor QEA and Integral 2010) described the rationale for selection of data to be used in the baseline risk assessments. Data to be used in baseline risk assessments should be of known quality, which includes only Category 1 data (as described in Section 3 of the RI/FS Work Plan), and should reflect recent but pre-remediation (baseline) conditions. Based on a temporal analysis of surface sediment data in the area around the northern impoundments (Integral 2011a) and as established in the PSCR (Integral and Anchor QEA 2012b), data collected in 2005 or earlier are not considered reflective of recent conditions and were not considered representative of baseline conditions for purposes of this BHHRA.

Data from within USEPA's Preliminary Site Perimeter and background data were used in the risk assessment. Analysis of background information allows for consideration of other potential sources of COPCHS, and is relevant for the evaluation of remedial alternatives and for risk management decisions at the Site.

The baseline dataset for the BHHRA consists of:

- Sediment, tissue, and soil data collected for the RI/FS.
- Sediment and surface water data collected by URS (2010) for TCEQ in 2009.
- Polychlorinated biphenyl (PCB) congener data for fish tissue and sediments collected by TCEQ in 2008 and 2009 as part of the total maximum daily load (TMDL) program (University of Houston and Parsons 2009; Koenig 2010, Pers. Comm.)<sup>8</sup>

The background dataset consists of:

- Sediment, tissue, and soil data collected for the RI/FS in background areas.
  - Sediment—Sediment from 10 intertidal locations upstream from the upper boundary of USEPA's Preliminary Site Perimeter. Subtidal sediment samples from upstream were not used in this BHHRA.
  - Tissue—Edible crab and catfish tissue from Cedar Bayou and from fish collection area (FCA) 5 in the San Jacinto River estuary south of the Fred Hartman Bridge. Clams were collected along two sections of shoreline upstream of the upper boundary of USEPA's Preliminary Site Perimeter, downstream of the mouth of the San Jacinto River.
  - Soil—Soil from locations in two general areas; Burnet Park and the I-10 Beltway 8 Green Space.
- PCB congener data collected by TCEQ in 2008 and 2009 as part of the TMDL program from stations downstream of USEPA's Preliminary Site Perimeter and in proximity to the Fred Hartman Bridge (University of Houston and Parsons 2009; Koenig 2010, Pers. Comm.)<sup>4</sup>

A comprehensive discussion of background data is included in the RI Report (Integral and Anchor QEA 2012a).

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<sup>8</sup> Appendix A to the EAM (Integral 2012a) documents Integral's independent validation of TCEQ's PCB congener data according to procedures applicable to the RI/FS. This validation effort resulted in a change to the classification of these PCB data from Category 2 to Category 1.

### **3.1.2 Data Types**

Data used in a BHHRA should represent conditions in environmental media that human receptors could potentially contact. The data types used to characterize each medium of interest are briefly discussed below. This information was presented in the EAM (Appendix A), and is summarized here for completeness.

#### **3.1.2.1 Sediment**

Fishers and recreational visitors may have the potential to be exposed to surface sediment in accessible shoreline areas within USEPA's Preliminary Site Perimeter. There is a limit to the water depth into which these individuals would wade during these activities. To determine the boundary of the sediment that might result in direct contact exposures, bathymetry contours were mapped. The 2-foot depth contour (i.e., sediment covered by 2 feet or less of water) was considered the outer boundary of sediments that people would contact directly.<sup>9</sup> All shoreline and nearshore sediment data covered by 2 feet or less of water were used to evaluate exposure to sediment for the fishing and recreational scenarios. As outlined in the Sediment SAP (Integral and Anchor QEA 2010) and EAM (Integral 2012a), sediment samples collected from the 0- to 6-inch depth increment were used to evaluate exposure to humans.

#### **3.1.2.2 Tissue**

The tissues collected under baseline conditions to evaluate potential human exposures (Integral 2010b) included hardhead catfish fillet (skin removed), edible crab tissue, and edible clam tissue. Hardhead catfish fillet data were used to estimate exposures resulting from the ingestion of finfish. Edible crab and clam tissues were used to estimate exposures via shellfish ingestion.

There is uncertainty regarding the representativeness of available fish tissue data for characterizing potential exposures via ingestion that could have occurred under baseline conditions. There is no information regarding the extent to which various fish and shellfish types are collected from within USPEA's Preliminary Site Perimeter and consumed. The use of hardhead catfish to represent all human exposure to finfish results in a conservative

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<sup>9</sup> The tidal condition at which the 0 foot contour was established is not known. This results in some uncertainty in the determination of sediment locations that are representative of human exposure.

upper-end exposure for fishers consuming finfish. This is because hardhead catfish are benthic fish that tend to accumulate higher concentrations of persistent bioaccumulative compounds than do fish that live and feed in the water column within the same waterbody (e.g., USEPA 2009a). Uncertainties associated with the representativeness of tissue data designated for this BHHRA and the likelihood of consumption of this species alone are explored in the uncertainty evaluation completed as part of the risk characterization (Section 5).

### 3.1.2.3 Soil

Fishers, recreational visitors, and trespassers have potential for exposure to COPCHs in soils in the impoundments north of I-10, while trespassers and workers may be exposed to COPCHs in soils in the area of investigation south of I-10. Fishers, recreational visitors, and trespassers are anticipated to participate in activities that would potentially bring them into contact only with surface soils. Workers, however, may have contact with a combination of surface and shallow subsurface soils during outdoor maintenance activities. Under the soil investigations completed for the RI, soil from a variety of depth increments was collected at various locations (Integral 2011b,c).

Soils representing the surface condition (i.e., those collected from surface increments of 0 to 6, 0 to 8, 0 to 12, and 0 to 24 inches) were used to evaluate potential exposure for fishers, recreational visitors, and trespassers. For workers in the area of investigation on the peninsula south of I-10, data from these increments, as well as from the shallow subsurface increment of 6 to 12 inches, are used in the exposure evaluation.

## 3.2 Data Treatment

RI/FS data are managed according to the project Data Management Plan (DMP), which is Appendix A to the RI/FS Work Plan (Integral and Anchor QEA 2012b). For performance of various analyses in this BHHRA, general data treatment rules are as follows:

- 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) toxicity equivalent (TEQ) concentrations for dioxins and furans (i.e., as TEQ<sub>DF</sub>) and PCBs (i.e., as TEQ<sub>P</sub>) were calculated using the toxicity equivalency factors (TEFs) for mammals (Table 3-2) (van den Berg et al. 2006, USEPA 2010d).

- TEQ concentrations in samples for which one or more dioxin-like congener was not detected were calculated in two ways. Under the first approach, censored data (i.e., nondetects) were assumed to be equal to one-half of the estimated detection limit for each congener. Under the second approach, nondetects were assigned a value of zero.
- Total PCBs in tissue were calculated as the sum of the 43 PCB congeners listed in Table 3-3. In cases in which additional PCB congeners co-eluted with the 43 specified congeners, these additional congeners were included in the summing to derive the total PCB concentration.
- In soil samples in which one or more Aroclor was detected, total PCBs were calculated as the sum of detected Aroclor concentrations only. When no Aroclors were detected, total PCBs for each sample was estimated at one-half the maximum detection limit among all Aroclors in the sample.<sup>10</sup> This rule was not applied to the calculation of total PCBs in sediment because of elevated detection limits in these samples. The treatment of total PCBs in sediment is discussed further below.
- For TEQ and total PCB metrics, if the concentration of one or more individual constituent (i.e., congener or Aroclor) included in the summation was an estimated value, then the summed total was reported as estimated (J-qualified). If all constituents were not detected in a sample, then the summed concentration was reported as not detected (U-qualified). If one or more constituent was not detected, then the resulting total estimate was reported as estimated (J-qualified).
- One hundred percent of mercury detected in tissue was assumed to be methylmercury. For soil and sediment, it was assumed that 100 percent of mercury detected was an inorganic form.<sup>11</sup>
- Ten percent of arsenic detected in tissue was assumed to be inorganic arsenic. The remaining 90 percent was assumed to be in an organic form.<sup>12</sup> One hundred percent of the arsenic measured in soils and sediments was assumed to be inorganic arsenic.

<sup>10</sup> This approach is consistent with methods used in a recent BHHRA for the Lower Duwamish Waterway, in Seattle, Washington. PCBs are a COC for that Site. This BHHRA was approved by USEPA in 2007 (Windward 2007).

<sup>11</sup> These treatments are consistent with USEPA guidance (2010b) and the approaches taken by the Texas Department of State Health Services (TDSHS) Seafood and Aquatic Life Group (SALG) (TDSHS 2008).

<sup>12</sup> This treatment is consistent with the state of knowledge regarding the proportions of inorganic and organic arsenic in fish tissues (USEPA 2003b; ATSDR 2007) and approaches taken by TDSHS's SALG (TDSHS 2008).

- Any nondetects for a given analyte and medium that were higher than the maximum detected concentration for the same analyte and medium were considered “high-biasing non-detects,” and were removed prior to use of the dataset in this BHHRA, as outlined in USEPA (1989) guidance.

The data treatment rule described above for calculation of total PCBs as Aroclors (i.e., calculated as the sum of detected Aroclors or as one-half of the highest detection limit among Aroclors when no Aroclors were detected) was not applied to estimate total PCBs for sediment because of analytical uncertainty for that dataset. Both Aroclors and dioxin-like PCB congeners were analyzed in sediment samples collected for the RI, consistent with the Sediment SAP (Integral and Anchor QEA 2010).<sup>13</sup> In the analysis of some of the sediment samples collected for the RI from within the 1966 perimeter of the northern impoundments (including core samples), matrix interference resulted in elevated detection limits for Aroclors. Among all of the sediment samples in the 1966 perimeter, Aroclors were only detected in one sample, including those with matrix interferences. This single estimated (J-qualified) concentration of 1,400 µg/kg was for Aroclor 1254 in a subsurface (2-4 feet) sediment sample collected during the RI at station SJGB014. This estimated concentration was lower than the elevated detection limit for this Aroclor in two of the stations where matrix interferences occurred and detection limits were elevated, but much higher than nondetects in the same core with normal detection limits. Because this sample provided the only indication of Aroclors in sediments within USEPA’s Preliminary Site Perimeter, and sediment EPCs for total PCBs were needed for the risk assessment, the sediment EPC for total PCBs was conservatively estimated as one-half the detection limit for Aroclor 1254 in each sample, with all other Aroclors estimated at zero.

This approach is considered conservative because highly elevated PCB concentrations are unlikely on the basis of samples collected from within the wastes in the western cell of the northern impoundments prior to initiation of the RI (TCEQ and USEPA 2006). In that study, Aroclors were never detected, even though Aroclor detection limits were much lower (<90 µg/kg). Elevated Aroclors are also considered unlikely based on results for several

<sup>13</sup> The USEPA comment requiring evaluation of exposures to total PCBs as the sum of 43 specific congeners was first articulated in the comments on the Tissue SAP, which was produced after the Sediment SAP was final and implemented. See Appendix C of the Tissue SAP (Integral 2010b).

samples with normal Aroclor detection limits that were collected for the RI at the same time and even in the same core as those with interferences. For example, in SJGB011, Aroclor 1254 in the sample from 6 to 8 feet (182 to 243 cm) deep was not detected at a detection limit of 2,250  $\mu\text{g/kg}$ , but in the same core, in the sample interval from 10 to 12 feet (304 to 350 cm) deep, Aroclor 1254 was not detected at a detection limit of 9.5  $\mu\text{g/kg}$ . In summary, there is uncertainty about the actual Aroclor concentrations in the materials collected from within the 1966 perimeter of the northern impoundments. However, the absence of Aroclor detections in sediment or waste samples collected by TCEQ and USEPA (2006), and in other samples closely proximal to the samples that had matrix interferences, confirms that the approach taken to estimating total PCBs in sediment is conservative.

In the calculation of exposure point concentrations (EPCs) and in statistical evaluations of the datasets (e.g., characterization of data distributions), specific rules were applied for estimating values for censored data. Data distributions for each medium in each exposure unit were tested using the Shapiro-Wilk test for normality (Johnson et al. 2007). Procedures for substituting values for censored data varied, depending on the sample size and the detection frequency, as follows:

- For each dataset used in calculation of an EPC, the detection frequency was calculated as the percentage of values not flagged with a "U" qualifier (not detected).
- Nondetects in datasets with sample sizes equal to or greater than 10 and detection frequencies equal to or greater than 50 percent were set to one-half the detection limit and were included in all calculations.
- Datasets with sample sizes equal to or greater than 10 and detection frequencies between 20 and 50 percent were addressed using statistical substitution methods. The substitution method used depended on the distribution of the dataset; for normally or lognormally distributed data, upper confidence limits on the mean (UCLs) were estimated using robust regression on order statistics (Helsel 2005); for datasets with unknown data distributions (those that could not be defined as normal or lognormal), a nonparametric Kaplan-Meier approach for inputting nondetects was used (Helsel 2005; Singh et al. 2006).
- Nondetects in datasets with sample sizes less than 10, regardless of detection frequency, or in datasets with detection frequencies less than 20 percent, regardless of sample size, were not subject to statistically derived substitutions because the pool

from which information about the data distribution could be drawn was insufficient for robust substitution methods. These datasets were treated with nondetects substituted at one-half the detection limit.

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## 4 TOXICITY ASSESSMENT

The toxicity assessment summarizes the health effects that may be associated with exposure to the COPCHs selected for the risk assessment and identifies doses that may be associated with those effects. Toxicological criteria are numerical expressions of dose and response and are used along with estimates of exposure to calculate potential risks to human receptors. These criteria may differ, depending on the duration and route of exposure. Therefore, the toxicological criteria required for this BHHRA were selected to reflect exposure routes represented in the CSMs. Toxicological criteria for cancer and noncancer effects are available.

The TESM (Integral 2012b; Appendix B) presents the cancer- and noncancer-based toxicological criteria that were used in this BHHRA for the COPCHs identified for the area north of I-10 and aquatic environment, as well as for thallium.<sup>14</sup> At the time the TESM was prepared, sampling efforts for the area of investigation on the peninsula south of I-10 were ongoing and the complete set of COPCHs for this area had not yet been developed. Additional COPCHs for the area of investigation on the peninsula south of I-10 are identified in Appendix C and toxicological criteria for the additional COPCHs are documented in Appendix D of this BHHRA. The cancer- and noncancer-based toxicological criteria selected for all COPCHs are summarized in Tables 4-1 and 4-2, respectively.

This section describes the methods that were used for selecting toxicological criteria for the final COPCHs, and provides a summary of the bases of the criteria selected. Because the toxicity of dioxin-like compounds (DLCs) is expressed in this BHHRA using TEQ values, a brief overview of the TEQ approach, which relates to the mechanism of action by which these compounds are believed to act and to the relative potency of the various DLCs, is also provided below.

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<sup>14</sup>Thallium was not selected as a COPCH for the northern impoundments; however, the maximum concentration of thallium measured in the area of investigation in the peninsula south of I-10 during the Phase 1 2011 soil sampling event exceeded the industrial screening value. Although this maximum concentration was measured in a deep subsurface soil sample (i.e., 8-foot interval), thallium was addressed in the TESM in anticipation that it might be identified as a COPCH for the area of investigation in the peninsula south of I-10. Ultimately, thallium was not selected as a COPCH, and, therefore, it is not discussed further in this toxicity evaluation.

## 4.1 Hierarchy for Selecting Toxicological Criteria

In accordance with procedures outlined by USEPA (2003a), the following hierarchy of sources was considered in selecting toxicological criteria for this BHHRA, in order of preference:

- Tier 1: USEPA's IRIS<sup>15</sup>
- Tier 2: USEPA's Provisional Peer Reviewed Toxicity Values from the National Center for Environmental Assessment/Superfund Health Risk Technical Support Center<sup>16</sup>
- Tier 3: Other USEPA and non-USEPA sources, such as the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels<sup>17</sup>, USEPA's Health Effects Assessment Summary Tables (HEAST; USEPA 1997b), California Environmental Protection Agency values,<sup>18</sup> and other sources that are current, publicly available, and have been peer reviewed.

## 4.2 Toxic Equivalency Factors for Dioxin-Like Compounds

In all, there are 75 dioxins and 135 furans that are differentiated by the numbers and positions of the chlorine atoms present. Seventeen of those congeners have chlorine substitutions in the 2,3,7,8- positions of the molecule. It is widely believed that toxicity of these 17 congeners occurs through a common biochemical mechanism, one that is initiated by the binding of the congener to the aryl hydrocarbon receptor (AhR), and leads to alterations in gene expression and signal transduction that are believed to be the biochemical determinants of toxic effects (Birnbaum 1994). Similarly, 12 coplanar PCB congeners have been shown to act via the same AhR mechanism and, therefore, are considered to be "dioxin-like." Of the 17 dioxin and furan congeners and 12 coplanar PCB congeners, TCDD has been the most extensively studied and exhibits the greatest potential for toxicity. Toxicological information on the other DLCs is more limited.

Because of the limited toxicological information for many of these DLCs, the TEQ approach was developed. Under the TEQ approach, the magnitude of toxicity of each of the dioxin-

<sup>15</sup> Available at: <http://www.epa.gov/ncea/iris/>.

<sup>16</sup> Values available at: <http://hhpprtv.ornl.gov/>

<sup>17</sup> Available at: <http://www.atsdr.cdc.gov/mrls/index.asp>

<sup>18</sup> Available at: [http://www.oehha.ca.gov/air/hot\\_spots/tsd052909.html](http://www.oehha.ca.gov/air/hot_spots/tsd052909.html)

like congeners is related to the toxicity of TCDD using a congener-specific toxic equivalency factor (TEF). The concentration of each congener is converted to an equivalent concentration of TCDD by multiplying the concentration of the congener by its TEF to derive a TEQ concentration for that congener. The congener-specific TEQs are then added together to compute the total TEQ concentration of the mixture of dioxins and furans (i.e., TEQ<sub>DF</sub>) and of dioxin-like PCBs (i.e., TEQ<sub>P</sub>). The resulting TEQ concentrations provide the metric to be used in evaluating exposure to the mixtures.

While there are substantial uncertainties associated with the use of TEQs (see Appendix B), USEPA generally requires that the TEQ approach be used to evaluate the risks due to mixtures of dioxins and furans. The TEQ approach therefore has been used in this BHHRA to estimate potential health effects associated with mixtures of dioxins and furans, and dioxin-like PCBs.

### 4.3 Cancer Effects

USEPA evaluates the potential for individual chemicals to cause cancer in humans. An initial step in this evaluation is a qualitative, weight-of-evidence (WOE) evaluation of the extent to which a chemical is believed to be a human carcinogen based on the results of human and/or animal studies. For those chemicals that have been categorized as known or probable carcinogens, USEPA typically develops chemical-specific cancer slope factors (CSFs), which are upper-bound estimates of the carcinogenic potency. These CSFs are used to estimate the incremental risk of developing cancer, corresponding to a lifetime of exposure at the levels described in the exposure assessment. Under USEPA's standard default risk assessment procedures, estimates of carcinogenic potency reflect the conservative assumption that there is no threshold dose for carcinogenic effects; that is, there is no entirely "safe" dose and exposure to any amount of the chemical will contribute to an individual's overall risk of developing cancer during a lifetime.

USEPA's *Guidelines for Carcinogen Risk Assessment* (2005), however, recognizes that some carcinogens act in a manner within the body (i.e., a mode of action) that follows a nonlinear, threshold response, similar to the threshold dose assumed when developing toxicological criteria for noncancer effects. A nonlinear dose-response relationship is one in which a level of exposure exists at which there is no increased risk of cancer within the exposed population

so that only exposure levels that exceed the threshold dose will result in an increased probability of developing cancer. USEPA allows for estimates of carcinogenic potency to be based on a non-linear model when sufficient evidence exists to support a non-linear mode of action for the general population and any subpopulations of concern (USEPA 2005).

#### **4.3.1 Dioxins and Furans**

No Tier 1 or Tier 2 criterion is available to evaluate the potential carcinogenic effects of TCDD and other DLCs. Therefore, it was necessary to consider Tier 3 sources in selecting a cancer-based criterion for use in this BHHRA.

USEPA has been conducting an assessment of dioxin risks (the “dioxin reassessment”) for nearly 20 years, but this process is not yet complete. During this period, there has been extensive, worldwide evaluation of the toxicological literature for dioxin and furans, and substantial disagreement remains within the scientific community as to the appropriate approach for estimating the toxicological potential of these compounds. Available Tier 3 values vary widely in both magnitude and approach, as discussed in Appendix B.

The available Tier 3 values for the carcinogenic potential of TCDD can be broken into two categories. The first category includes those criteria that are based on the assumption that a CSF for TCDD should be derived using a linear dose response model. The second category includes those toxicological criteria that are based on the assumption that there is a threshold dose for TCDD’s carcinogenic activity so that this threshold must be reached before TCDD can exert a carcinogenic effect.

USEPA has historically used a linear dose response model to evaluate the potency of TCDD and other DLCs. There is, however, a growing consensus worldwide, including among members of USEPA’s Science Advisory Board (SAB) and the National Academies of Sciences, that there is likely a threshold for TCDD’s carcinogenicity and that it should be evaluated using a nonlinear, threshold approach (WHO 1998; JECFA 2002; Simon et al. 2009; NAS 2006; ACC 2010; TCEQ 2010a,b, 2011; Haney 2010).

For this BHHRA, a threshold based tolerable daily intake (TDI) of 2.3 pg/kg-day was used to evaluate potential cancer effects resulting from assumed exposure to dioxins and furans. The Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives (JECFA) derived a threshold-based toxicity criterion for TCDD based on body burden rather than on administered dose. This committee included individuals from the U.S. Food and Drug Administration (U.S.), Health Canada (Canada), the National Institute of Public Health and the Environment (Netherlands), Municipal Institute of Medical Research (Spain), Chemisches und Veterinäruntersuchungsamt (Germany), Scientific Directorate on Human Nutrition and Food Safety of the National Institute for Agricultural Research (France), Center for Risk Management (U.S.), and the National Institute of Public Health and the Environment (Netherlands). These individuals reviewed all of the available scientific literature related to the toxicology of dioxins and furans in both animals and humans that was available at that time. Based on their comprehensive review and analysis, the committee concluded that there was a threshold for all toxic effects associated with exposure to TCDD, including cancer, and that developmental effects represented the most sensitive of all of the toxic endpoints. They concluded that a toxicological criterion based on noncancer effects would also address any potential cancer risk. This conclusion was supported by the subsequent studies conducted by Simon et al. (2009) and NTP (2006).

JECFA concluded that the tolerable monthly intake of 70 pg/kg-month (equivalent to a TDI of 2.3 pg/kg-day) was a reliable value from animal studies that could be used to assess both cancer and noncancer effects of dioxin. Because this value was developed by an expert panel, USEPA (2010a) considers it to be adequately peer reviewed so that it represents a Tier 3 value. This value is well-supported by the toxicological literature and an international panel of scientists, and is consistent with SAB comments on the dioxin reassessment and the opinions of other toxicologists who support the use of a threshold approach in developing toxicological criteria for DLCs (NAS 2006; Simon et al. 2009; TCEQ 2009, 2010a, 2011). This value was used to evaluate the potential carcinogenic effects of TEQ<sub>DF</sub> in this BHHRA.

Alternative Tier 3 criteria derived from linear dose response models were presented and discussed in the TESM (Appendix B). These were used for calculating cancer risks that are presented and discussed as part of the uncertainty evaluation.

### 4.3.2 PCBs

PCBs are a large family of 209 related congeners. These compounds range from mono-chlorinated congeners (having only one chlorine atom) to fully substituted deca-chlorinated congeners (with chlorine at all possible ring locations). Most of the PCBs that are found in the environment were released as commercial mixtures that were originally sold in the U.S. under the trade name Aroclor. Generally, Aroclors were identified by trade names such as Aroclor 1254.

According to USEPA, the cancer potency of PCB mixtures depends on the media of interest and the PCB congeners present. USEPA's Integrated Risk Information System (IRIS) database provides an upper bound CSF of  $2 \text{ (mg/kg-day)}^{-1}$  and central tendency CSF of  $1 \text{ (mg/kg-day)}^{-1}$  for PCB mixtures. These CSFs were used to estimate upper-bound and central tendency cancer risks, respectively, associated with total PCBs (either sum of 43-congeners<sup>19</sup> or sum of Aroclors).

In addition, TEFs have been developed for the 12 PCB congeners that are assumed to be DLCs because they also have a high affinity to bind to the AhR. Therefore, for the uncertainty analysis, an equivalent concentration of TCDD for the PCB mixture (i.e., TEQ<sub>P</sub>) was evaluated using the toxicological criterion for TCDD.

### 4.3.3 Other COPCs

IRIS provides CSFs of  $0.014 \text{ (mg/kg-day)}^{-1}$  for bis(2-ethylhexyl)phthalate and  $1.4 \text{ (mg/kg-day)}^{-1}$  for inorganic arsenic (Table 4-1). These values were used to evaluate the potential carcinogenic risks due to these COPCHs. The bases of these values are provided in the TESM (Appendix B).

In addition to a subset of the COPCHs already identified for the area north of I-10 and aquatic environment, benzo(a)pyrene was identified as a COPCH for the area of investigation south of I-10. IRIS provides a CSF for benzo(a)pyrene of  $7.3 \text{ (mg/kg-day)}^{-1}$ . The basis of this value is provided in Appendix D, *Supplemental Toxicological and Chemical-Specific Parameters*

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<sup>19</sup> Total PCB concentrations were calculated as the sum of the 43 congeners shown in Table 3-3.

All other COPCHs are not considered to have carcinogenic potential via oral exposure routes and, therefore, were not included in the estimation of potential cancer risks.

#### **4.4 Noncancer Effects**

For chemicals that are considered to have the potential to cause noncancer health effects, toxicological criteria are based on the adverse health effect elicited at the lowest doses evaluated in animal or human studies. The dose level at which no adverse effects are observed (i.e., the no-observed-adverse-effect level [NOAEL]), or the lowest dose tested at which adverse effects are observed (i.e., the lowest-observed-adverse-effect level [LOAEL]), is the point of departure (POD) for developing noncancer toxicological criteria. Uncertainty and/or modifying factors are typically applied to the POD to adjust for uncertainties in the toxicity data, differences in responses among animal species and humans, and variations in inter-individual sensitivity within the human populations. This provides a margin of safety to ensure that the estimated dose level selected as the criterion will not result in adverse health effects in the exposed human population. The resulting toxicological criterion, known as the reference dose (RfD), is the dose level at or below which no adverse health effects are expected to occur.

To evaluate potential noncancer health effects that may result from exposure to a chemical, the potential hazard is evaluated by comparing the estimated daily intake with an RfD. RfDs are available for different durations of exposure. For long-term exposures, this is identified as a chronic RfD. USEPA (1989) defines the chronic RfD as a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Subchronic RfDs are used to evaluate potential noncancer hazards associated with exposures of less than 7 years.

##### **4.4.1 Dioxins and Furans**

USEPA's IRIS database provides an RfD of 0.7 pg/kg-day for TCDD based on developmental effects reported by two epidemiological studies (Table 4-2). This criterion was used to evaluate the potential noncancer hazards associated with TEQ<sub>DF</sub>.

#### **4.4.2 PCBs**

USEPA's IRIS database provides an RfD of  $2 \times 10^{-5}$  mg/kg-day for Aroclor 1254-based changes in immune response measured in rhesus monkeys dosed with Aroclor 1254 compared to controls. This criterion was used to evaluate potential noncancer hazards due to exposures to total PCBs (i.e., sum of 43-congeners or sum of Aroclors) in Site-related media.

IRIS does not discuss the approach to be used for evaluating noncancer effects of dioxin-like PCB congeners and USEPA has not yet made any policy statements about the adoption of the RfD for TCDD for PCB risk assessment. In addition, there is no indication that the endpoints that were selected as the basis for the TCDD RfD are also associated with PCB toxicity. This means that the application of the TCDD RfD to dioxin-like PCBs is likely to result in substantial uncertainty in estimates of the risks due to PCBs. However, in the event that USEPA may require that the TEQ approach also be used to evaluate noncancer effects of total TEQ mixtures, an evaluation of noncancer hazards using this approach was completed and discussed in the uncertainty analysis.

#### **4.4.3 Other COPCs**

IRIS provides chronic RfDs for the remainder of the COPCHs for the area north of I-10 and the aquatic environment and the area of investigation south of I-10 with the exception of organic forms of arsenic and copper. The chronic RfDs for organic arsenic and copper were taken from ATSDR and HEAST, respectively (Table 4-2). These RfDs were used for evaluating potential chronic exposures to these COPCHs. The critical endpoint for each COPCH is also provided. The specific bases of these values are provided in the TSM (Appendix B).

#### **4.4.4 Subchronic Noncancer Effects**

Subchronic RfDs are used to evaluate potential noncancer hazards associated with exposures between 2 weeks and 7 years (USEPA 1989). The trespasser scenario for the area of investigation south of I-10 represents the only scenario with exposure durations in this range and where subchronic exposures are therefore relevant. Although there is generally adequate information on toxicological criteria to evaluate long-term or chronic exposures, information on subchronic exposures is more limited. No subchronic RfDs are available for any of the

COPCHs identified for the noncancer evaluation (i.e., for dioxins and furans and for inorganic arsenic); therefore, the chronic RfDs were used to evaluate potential noncancer hazards associated with the hypothetical trespasser scenario (Table 4-2). As discussed in Appendix D, no published subchronic RfD is available for benzo(a)pyrene. Therefore, this chemical was evaluated for its carcinogenic potential only.

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## **5 EXPOSURE AND RISK CHARACTERIZATION FOR AREA NORTH OF I-10 AND AQUATIC ENVIRONMENT**

This section presents the exposure assessment and risk characterization for the area north of I-10 and the aquatic environment. The purpose of the exposure assessment (Section 5.1) is to estimate the type and magnitude of potential human exposure to COPCs identified at a site. In the risk characterization (Section 5.2), these estimates of exposure are combined with toxicological criteria to yield numerical estimates of potential adverse health effects to humans.

### **5.1 Exposure Assessment**

For this BHHRA, potential exposures under the baseline condition (i.e., immediately prior to the TCRA) were first estimated using deterministic methods. The exposure scenarios, algorithms, and assumptions used for the deterministic assessment were established and discussed in the EAM (Appendix A) and are summarized below. For risk assessment purposes, the baseline levels of exposure are assumed to apply throughout the exposure duration for each hypothetical scenario, even though there is no basis for assuming that baseline represents conditions that existed at any other point in time, or that would have continued to exist in the absence of the TCRA.

This set of assumptions was also used for estimating background and post-TCRA exposures for those scenarios that were selected for further analysis (i.e., see Figure 1-4). For any scenario selected for further analyses, potential exposures for each component exposure pathway were additionally estimated using probabilistic methods. The inputs for probabilistic analysis are briefly discussed below and are presented in detail in Appendix G.

#### **5.1.1 Exposure Scenarios**

Three potential receptor groups were assumed for the quantitative risk assessment for the area north of I-10 and the aquatic environment: a hypothetical recreational fisher, a hypothetical subsistence fisher, and a hypothetical recreational visitor. Based on the CSM for the area north of I-10 and aquatic environment, the following potential exposures were quantified for these hypothetical receptor groups:

- Recreational Fisher—direct contact (incidental ingestion and dermal contact) with sediment and soils, ingestion of finfish, and ingestion of shellfish
- Subsistence Fisher—direct contact with sediment and soils, ingestion of finfish, and ingestion of shellfish
- Recreational Visitor—direct contact with sediment and soils.

Both hypothetical recreational and subsistence fishers are assumed to ingest fish and/or shellfish caught within USEPA's Preliminary Site Perimeter. Detailed information regarding fishing activities and consumption patterns in the area is not available. In the absence of this specific information on consumption of fish from the area, exposures were estimated separately under three general scenarios: 1) finfish ingestion only, 2) clam ingestion only, and 3) crab ingestion only. Focusing the risk assessment on single-tissue type exposures is conservative because it identifies and quantifies potential exposure to the tissue type that result in the highest potential for exposure. In estimating cumulative exposure, estimated exposures from the direct contact pathways (i.e., ingestion and dermal contact) were summed with exposures for each tissue ingestion scenario separately.

A series of hypothetical exposure scenarios were considered for each receptor based on tissue type ingested as well as the exposure units defined for sediments. The exposure units identified, and resulting scenarios evaluated for this risk assessment are described below.

#### **5.1.1.1 Exposure Units**

An exposure unit is defined as the area within which the receptor group being evaluated is expected to move and encounter environmental media for the duration of the exposure (USEPA 2002a). Selection of exposure units should also consider the statistical characteristics of the datasets (USEPA 2002a) where concentrations of COPCs in environmental media vary spatially; exposure units are selected to allow the risk assessment to distinguish between those areas of a site that present higher potential for risk to the exposed population and those areas that present lower potential risks. Such a distinction can facilitate risk management decisions by indicating which areas are associated with the highest risk, and therefore, which areas should be prioritized for risk reduction.

Exposure units for this BHHRA were identified by following the DQOs established in the RI/FS Work Plan (Anchor QEA and Integral, 2010) and in the Tissue SAP (Integral 2010b). The process used to define exposure units and the results of that analysis are documented in detail in the EAM (Appendix A). Figures 5-1 through 5-3 show the exposure units identified for baseline sediments, tissue, and soils respectively. Nearshore sediment samples were collected as part of the RI from five beach areas within USEPA's Preliminary Site Perimeter. A statistical analysis of the available data indicated that, except for Beach Areas B and C, the sediment concentrations in these areas were sufficiently different that they should not be combined (Figure 5-1) (Appendix A, Section 3.4). Three FCAs were identified at the Site (Figure 5-2). Statistical analysis of the fish tissue data indicated that FCAs 2 and 3 could be combined for catfish fillets and crabs, and FCAs 1 and 3 could be combined for clams (Appendix A, Section 3.4). For soils a single exposure unit was defined. Figure 5-3 shows the locations of the samples used to define this exposure unit. The selection of a single exposure unit for soils north of I-10 was based on the assumption that individuals visiting the area north of I-10 could have direct contact with soils in all of the sample collection areas during their visit.

Based on the analysis summarized above, the following exposure units were defined for the baseline condition:

- Sediments
  - Beach Area A
  - Beach Area B/C—consisting of data pooled from Beach Areas B and C
  - Beach Area D
  - Beach Area E
- Hardhead catfish fillet
  - FCA 2/3—consisting of data pooled from FCA 2 and FCA 3
  - FCA 1
- Edible crab
  - FCA 2/3—consisting of data pooled from FCA 2 and FCA 3
  - FCA 1

- Edible clam
  - FCA 1/3—consisting of data pooled from FCA 1 and FCA 3
  - FCA 2
- Soils
  - The entire area north of I-10

Fencing constructed as part of the TCRA now limits regular access to all Beach Areas except Beach Area A. Therefore, Beach Area A was defined as the only exposure unit for sediments under the post-TCRA condition. There is future potential for receptors to access Beach Areas B and C/D (e.g., in the case that a breach in the fencing was to occur). The impact of such access on potential exposure and associated risk under the post-TCRA condition is described in the uncertainty evaluation for this BHHRA. In addition, given this more limited access, a smaller area was considered as the post-TCRA exposure unit for soils. Figures 5-4 and 5-5 show the post-TCRA exposure units for sediments and soils, respectively. The exposure units assigned for post-TCRA tissue remain unchanged from baseline.

#### **5.1.1.2 Resulting Hypothetical Exposure Scenarios**

Exposure units for various media were combined to represent exposures that could hypothetically occur under the assumed conditions. For instance, hypothetical fishers at Beach Area A are assumed to have direct contact with sediments at Beach Area A, and to catch and ingest finfish from FCA 2/3, crabs from FCA 2/3, or clams from FCA 1/3. Hypothetical fishers at Beach Area D are assumed to have direct contact with sediments in Beach Area D and assumed to catch and ingest finfish from FCA 1, crabs from FCA 1, or clams from FCA 1/3. The complete set of hypothetical exposure scenarios evaluated for the baseline condition for this BHHRA is provided in Table 5-1.

#### **5.1.2 Estimates of Exposure**

This section presents the equations and exposure parameters that were used for estimating exposure for this BHHRA. USEPA (1993) guidance recommends that two types of exposure estimates be calculated. The reasonable maximum exposure (RME) is defined as the highest exposure that could reasonably be expected to occur for a given exposure pathway and scenario at a site. The RME is intended to account for uncertainty in the chemical

concentration at the point of exposure, and for variability and uncertainty in exposure parameters. USEPA also recommends that the central tendency exposure (CTE), or average estimate of exposure, be presented in a risk assessment. Both RME and CTE estimates were calculated for this BHHRA. In addition, for any exposure scenario that was selected for further evaluation (Figure 1-4), a PRA was employed to estimate exposure. The equations and exposure parameters used in the risk assessment are presented below.

#### 5.1.2.1 Equations

Three types of potential exposures were evaluated: 1) ingestion of sediment and/or soil, 2) dermal absorption of sediment and/or soil, and 3) ingestion of fish and/or shellfish. The equations that were used to calculate these potential exposures are presented below. The equations are common to both the deterministic and probabilistic evaluations.

#### **Equation 5-1. Intake via Ingestion of Soil and/or Sediment**

Relevant Receptor Groups: fishers, recreational visitors

$$I_{\text{soil-sed}} = \frac{[(C_{\text{soil}} \times IR_{\text{soil}} \times F_{\text{soil}}) + (C_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}})] \times RBA_{\text{soil-sed}} \times FI_{\text{soil-sed}} \times EF_{\text{soil-sed}} \times ED \times CF_1}{BW \times AT} \quad (\text{eq. 5-1})$$

Where:

$I_{\text{soil-sed}}$	=	intake, the mass of a chemical contacted in soil and sediment by the receptor per unit body weight per unit time (mg/kg-day)
$C_{\text{soil}}$	=	chemical concentration in soil contacted over the exposure period (i.e., EPC for soil) (mg/kg)
$IR_{\text{soil}}$	=	soil ingestion rate (mg/day)
$F_{\text{soil}}$	=	fraction of total ingestion that is soil (percent as a fraction)
$C_{\text{sed}}$	=	chemical concentration in sediment contacted over the exposure period (i.e., EPC for sediment) (mg/kg)
$IR_{\text{sed}}$	=	sediment ingestion rate (mg/day)

$F_{sed}$	=	fraction of total ingestion that is sediment (percent as a fraction)
$RBA_{ss}$	=	relative bioavailability adjustment for soil and sediment (percent as a fraction)
$FI_{soil-sed}$	=	fraction of total daily soil/sediment intake that is site-related (percent as a fraction)
$EF_{soil-sed}$	=	exposure frequency (days/year)
$ED$	=	exposure duration (years)
$CF_1$	=	conversion factor ( $1 \times 10^{-6}$ kg/mg)
$BW$	=	body weight (kg)
$AT$	=	averaging time (days)

**Equations 5-2 and 5-3. Dermal Absorbed Dose via Contact with Soil and Sediment**

Relevant Receptor Groups: fishers, recreational visitors

$$DAD_{soil-sed} = \frac{DA_{event} \times SA \times EF_{soil-sed} \times FI_{soil-sed} \times ED \times EV}{BW \times AT} \quad (\text{eq. 5-2})$$

Where:

$DAD_{soil-sed}$	=	dermal absorbed dose from soil and sediment (mg/kg-day)
$DA_{event}$	=	absorbed dose per event (mg/cm <sup>2</sup> )
$SA$	=	skin surface area available for contact (cm <sup>2</sup> )
$EV$	=	event frequency (day <sup>-1</sup> )

And,

$$DA_{event} = [(C_{soil} \times AF_{soil} \times F_{soil}) + (C_{sed} \times AF_{sed} \times F_{sed})] \times ABS_d \times CF_1 \quad (\text{eq. 5-3})$$

Where:

$AF_{soil}$	=	adherence factor for soil (mg/cm <sup>2</sup> )
$AF_{sed}$	=	adherence factor for sediment (mg/cm <sup>2</sup> )
$ABS_d$	=	dermal absorption factor for soil/sediment (percent as a fraction)

#### Equation 5-4. Intake via Ingestion of Fish and Shellfish

Relevant Receptor Groups: fishers

$$I_{\text{tissue}} = \frac{C_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times RBA_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2}{BW \times AT} \quad (\text{eq. 5-4})^{20}$$

Where:

$I_{\text{tissue}}$	=	intake, the mass of a chemical contacted in fish or shellfish tissue by the receptor per unit body weight per unit time (mg/kg-day)
$C_{\text{tissue}}$	=	chemical concentration in fish or shellfish tissue contacted over the exposure period (i.e., EPC for fish or shellfish) (mg/kg)
LOSS	=	chemical reduction due to preparation and cooking (percent as a fraction)
$IR_{\text{tissue}}$	=	fish or shellfish ingestion rate (g/day)
$RBA_{\text{tissue}}$	=	relative bioavailability adjustment for tissue (percent as a fraction)
$FI_{\text{tissue}}$	=	fraction of total fish or shellfish intake that is site-related (percent as a fraction).
$EF_{\text{tissue}}$	=	exposure frequency for fish or shellfish consumption (days/year)
$CF_2$	=	conversion factor ( $1 \times 10^{-3}$ kg/g)

#### 5.1.2.2 Deterministic Exposure Evaluation

The EPCs and exposure parameters selected for each scenario are summarized below and are discussed in detail in the EAM (Appendix A).

##### 5.1.2.2.1 Exposure Point Concentrations

EPCs were estimated for each medium in each exposure unit according to the procedures outlined in Section 3.2. Tables 5-2 through 5-4 summarize the RME and CTE EPCs used for the deterministic assessment of baseline risks. Table 5-5 shows the EPCs for the deterministic assessment of background risks. Supporting documentation for the EPC derivations, including summaries of the best-fit distribution and basic summary statistics for each dataset, is provided as Appendix E.

<sup>20</sup> The equation presented here uses the term tissue generically to present parameters for finfish and shellfish. Intake of finfish and shellfish were estimated separately.

Post-TCRA risks were evaluated for dioxins and furans only. Data or representative concentrations for all COPCHs in all media of interest for post-TCRA conditions were not available and, therefore, dioxins and furans were used to provide a relative measure of hazard and/or risk. EPCs representative of post-TCRA conditions for each medium were estimated using a variety of methods. For sediments and soils, the portion of the baseline data from within the exposure units defined for the post-TCRA condition (i.e., defined as the areas that were still accessible to individuals following the TCRA) were used. No tissue data were collected following the TCRA. In the absence of such data, post-TCRA tissue concentrations for hardhead catfish were estimated using statistical relationships between baseline sediment and tissue samples established in the *Technical Memorandum on Bioaccumulation Modeling* (Integral 2010c). For clams and crabs, where no meaningful model for predicting sediment-tissue relationships existed, assumptions regarding the baseline dataset were used to estimate post-TCRA EPCs. Appendix F documents the detailed methods used for post-TCRA EPCs as well as the post-TCRA risk characterization results and the uncertainties associated with these estimates.

#### 5.1.2.2.2 Exposure Parameters

This section provides an overview of the exposure assumptions used in the deterministic evaluation. A detailed presentation and the supporting rationales for these assumptions are included in the EAM (Appendix A). A summary of these exposure parameters is presented in Table 5-6. Assumptions adopted for chemical specific exposure parameters are provided in Table 5-7.

Differences in activity and intake parameters have been characterized for younger children, older children, and adults. Therefore, exposure parameters were developed separately for young children (ages 1 to <7 years), older children (ages 7 to <18 years), and adults (ages 18 years and older).

Considering the exposure factors assumed for this BHHRA, young children would have higher potential exposures (on a per unit body weight basis) relative to other age groups. Therefore, for the RME scenarios for all human receptor groups evaluated, it was assumed

that a portion of the total exposure occurs at these younger life stages. This is a conservative assumption because it results in an upper-bound RME scenario in which the calculated exposure for any alternative age grouping over the same chronic exposure duration would be lower. As established in the EAM, the individuals considered most likely to use the area under study under baseline conditions are adults. Therefore, for the CTE analysis, only adult exposures are evaluated.

### ***Common Parameters***

Given the lack of specific information on fishing and recreational behaviors within USEPA's Preliminary Site Perimeter, the exposure durations were conservatively based upon standard default assumptions used for residents. Default exposure durations of 33 years for the RME and 12 years for the CTE (USEPA 2011a) were based on studies of occupational mobility, and were adopted for this BHHRA.

Following common practice for human health risk assessment, the averaging time selected depended on the toxic endpoint (cancer or noncancer) being assessed. For noncarcinogens, the averaging time was set equal to the exposure duration (e.g., for an exposure duration of 6 years, the averaging time was 2,190 days). For carcinogens that were evaluated with a CSF, the averaging time was set equal to a lifetime (i.e., 78 years or 28,470 days) (USEPA 1989, 2011a). When the toxicity of a carcinogen was described using a criterion that assumed a threshold dose was required for an adverse effect to be elicited (i.e.,  $TEQ_{DF}$ ) the averaging time was set equal to the exposure duration. This latter approach described for threshold based carcinogens is essentially the same as the approach used for evaluating noncancer endpoints.

For the deterministic evaluation, mean body weights of 19, 50, and 80 kg were selected for the young child, older child, and adult age groups, respectively. These body weights were based on data collected from the 1999–2006, National Health and Nutrition Examination Survey (NHANES), and recommended in USEPA's Exposure Factors Handbook (2011a).

### ***Parameters for Tissue Ingestion***

Assumed fish and shellfish ingestion rates were selected from a study of fishing activity and consumption conducted in Lavaca Bay, Texas (Alcoa 1998). Lavaca Bay, which covers

roughly 40,000 acres, is part of the larger Matagorda Bay system. This system is similar in size to Galveston Bay and is situated further south along the Texas coastline. The demographics in the counties surrounding the two bays are similar (2010 Census data for Calhoun, Chambers, Galveston, Harris, Jackson, and Victoria counties).<sup>21</sup>

The Lavaca Bay study collected data about consumption rates, fraction ingested from a contaminated source area, and the species composition of the fish consumed. The study was conducted during the month of November, which was reported to be the month of highest fishing activity in the bay (Alcoa 1998) and nearly 2,000 anglers participated in the study. It was conducted for the specific use of supporting a risk assessment for the Alcoa Point Comfort/Lavaca Bay Superfund Site.

Lavaca Bay ingestion rates reported by Alcoa (1998) for finfish and shellfish were adopted for this BHHRA. They were selected because they are Texas-specific and represent consumption from a fishery that is similar to the fishery associated with the area inside USEPA's Preliminary Site Perimeter. For the hypothetical recreational fisher, mean rates were used for the CTE analysis, while the 95UCL rates were used for the RME analysis. Although the Lavaca Bay study did not identify a true subsistence population for that area, the study did present upper bound (90th or 95th percentile) estimates of ingestion rates for the surveyed groups. These rates were selected as RME ingestion rates for the hypothetical subsistence fisher. For each of these, the average of rates for men and women were assumed for the adult ingestion rates. The rates provided for youths in the study were used to evaluate the older child while the rates provided for small children were used to evaluate exposures to the young child. The exposure frequency for ingestion of tissue was assumed to be 365 days/year for all hypothetical fishers since the fish ingestion rates used were annualized average daily averages.

Given the relatively small spatial extent of the area within USEPA's Preliminary Site Perimeter compared to the size of the Galveston Bay fishery, it is unlikely that 100 percent of the fish consumed over the 33-year-exposure duration assumed for the RME would be harvested from the area of study. The survey conducted by Alcoa (1998) at Lavaca Bay

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<sup>21</sup> <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>

segregated the consumption data by the areas fished; specifically, a 1,500-acre subarea (indicated as the closure area), other portions of Lavaca Bay, and areas outside of Lavaca Bay. Similar to conditions at Lavaca Bay, the waters associated with USEPA's Preliminary Site Perimeter represent a very small fraction of the Galveston Bay fishery. Also like Lavaca Bay, there are many other locations around Galveston Bay that can be used for fishing. Therefore, the data from the Lavaca Bay survey were informative for the purposes of this BHHRA.

It was assumed that 25 percent of the total fish consumed by RME hypothetical recreational fishers, and 10 percent of total fish consumed by CTE hypothetical recreational fishers were collected from within USEPA's Preliminary Site Perimeter. These values were applied for the fractional intake term ( $FI_{\text{tissue}}$ ) for hypothetical recreational fishers in Equation 5-4, above. Their selection is conservative for this BHHRA, as less than one percent of the fish and shellfish consumed in Lavaca Bay was from the 1,500 acre sub-area being evaluated. A full discussion of the findings of the study is found in the EAM (Appendix A).

There was no information specific to the area within USEPA's Preliminary Site Perimeter available with which to estimate the fraction intake term ( $FI_{\text{tissue}}$ ) in Equation 5-4, above, for the hypothetical subsistence fisher. If subsistence activities did occur in this area, it is possible that fishers participating in these activities could fish exclusively from the waters adjacent to the area. Given the lack of information specific to fishing behaviors in the area of study, a conservative fractional intake of 1.0 was adopted for the subsistence fisher scenario.

#### ***Parameters for Direct Contact***

The majority of activity by a fisher was expected and assumed to occur along the water's edge so that substantial exposure to soil was not likely. Therefore, for the fishing scenarios, the fraction of total intake that was attributed to such soils was assumed to be zero, while the fraction of total daily intake from sediment was assumed to be 1.0 (100 percent). It was envisioned, however, that the recreational visitor who is not fishing might spend equal amounts of time in contact with soils and sediments. Therefore, the fraction of total exposures attributed to soils and sediments were both assumed to be 0.5 (50 percent).

Based on USEPA's (2011a) recommended ingestion rates for soil, soil and sediment ingestion rates of 20 mg/day were assumed for adults and used to evaluate both CTE and RME

estimates. An ingestion rate of 50 mg/day was assumed for older children. For younger children, a rate of 125 mg/day was assumed.<sup>22</sup>

For the skin surface area parameter, surface areas of 6,080 and 4,270 cm<sup>2</sup> were assumed for the older child and adult, respectively (USEPA 2011a), based on the assumption that an individual's hands, forearms, lower legs, and feet may come into contact with soil and/or sediment. For young children playing in the soil and/or sediment, it was assumed that the entire surface area of the leg might be in contact with sediments in addition to the hands, forearms, and feet. Based on this assumption for the young child, a surface area of 3,280 cm<sup>2</sup> was used (USEPA 2011A). The same surface areas were used to evaluate both the CTE and RME conditions.

Following USEPA recommendations, weighted adherence factors were calculated for each age group. These were based on the surface areas of the assumed, exposed body parts and body-part-specific adherence factors presented by USEPA (2011a) that were based on studies completed in sediment, and soil.

For sediment exposure estimates, weighted adherence factors of 3.6, 5.1, and 4.9 mg/cm<sup>2</sup> for young children, older children, and adults, respectively, were derived based on a study of children playing in sediment. The study was recommended by USEPA (2011a) and was one of the only available studies that investigated sediment adherence to skin. Given the difference in sediment types within USEPA's Preliminary Site Perimeter compared to those present in the study used to develop the factors presented in USEPA (2011a), and the importance of sediment type in predicting soil adherence (Spalt et al. 2008), uncertainty was introduced in the exposure estimates by the use of this factor. This uncertainty is further discussed within the uncertainty evaluation of the risk characterization.

A weighted soil adherence factor of 0.07 mg/cm<sup>2</sup> was calculated for older children and adults using data that described the adherence of soils to skin in adults participating in a variety of

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<sup>22</sup> Rates for the older child and young child are for the RME scenario. No child component was considered in the CTE scenario for the hypothetical recreational fisher and visitor. No CTE evaluation was completed for the hypothetical subsistence fisher scenarios.

activities (USEPA 2011a). Data from a study conducted in children exposed to soil were used to derive a soil adherence factor of 0.09 mg/cm<sup>2</sup> for young children (USEPA 2011a).

The assumed exposure frequency for the direct contact pathways was based on estimates of the number of trips to the area within USEPA's Preliminary Site Perimeter each year. According to the 2006 survey of Texas anglers conducted by the U.S. Fish and Wildlife Service (USFWS), the mean number of days spent fishing marine waters by Texas residents was 13 days/year (USFWS 2006). This value was assumed for the CTE exposure frequency for direct contact pathways for the hypothetical recreational fisher. It is reasonable to assume that more avid anglers may fish with a higher frequency than the average. A survey of Maine's freshwater anglers (Ebert et al. 1993), found that the 95th percentile frequency of fishing trips per year was nearly three times that of the average number of fishing trips per year. Based on this relationship, a RME frequency of 39 days/year was assumed for the hypothetical recreational fisher. It is reasonably anticipated that hypothetical subsistence fishers, if present, may participate in fishing activities more often than recreational fishers; however, it is not likely that they would fish the same location more than an average of 2 days per week, every week of the year, over the entire assumed exposure duration of 33 years. Thus, a RME exposure frequency for direct contact pathways of 104 days/year was assumed for the hypothetical subsistence fisher scenario.

In the absence of data concerning recreational use of the area within USEPA's Preliminary Site Perimeter, RME and CTE frequencies of 104 and 52 days per year, respectively, were assumed for hypothetical recreational visitors. These were based on assumed average frequencies of 2 days per week and 1 day per week throughout the course of the year, respectively.

It is not anticipated that a fisher's or a visitor's direct contact with soils and/or sediments would typically be limited to the area within USEPA's Preliminary Site Perimeter. These individuals would likely not spend the entire day on each day that they fish or visit within this area; rather they might spend only a few hours and spend the remainder of those days engaged in activities in other areas where they could be exposed to soils or sediment from areas outside of USEPA's Preliminary Site Perimeter. No information specific to the area of study is available with which to estimate the fractional intake term for soil/sediment ( $FI_{\text{soil-sed}}$ )

in Equation 5-1, above. Based on best professional judgment, a conservative fractional intake of 1.0 was adopted for the RME hypothetical recreational fisher and recreational visitor scenarios, and for the hypothetical subsistence fisher scenario. A fractional intake of 0.5 was adopted for the CTE scenario evaluated for the hypothetical recreational fisher and recreational visitor populations.

### **Chemical-Specific Factors**

In addition to the scenario-specific exposure assumptions described above, there are a number of chemical-specific factors that were required to estimate COPCH-specific exposure levels. These included oral bioavailability factors, dermal absorption factors, and reductions in chemical concentrations of certain COPCHs due to preparation and cooking. The chemical-specific values used are summarized in Table 5-7 and are briefly discussed below. A more comprehensive discussion of these parameters and the rationales for the values selected were included in the EAM (Appendix A).

### **Relative Oral Bioavailability**

Relative bioavailability adjustment (RBA) factors for oral pathways are used to account for the differences in chemical bioavailability in specific exposure media (i.e., soil, sediment, tissue) compared to the dosing vehicle used in the critical toxicity study that provides the basis for the COPCH-specific toxicity criteria selected for use in this BHHRA.

The RBA can be expressed as:

$$RBA = \frac{\text{absorbed fraction from exposure medium on site}}{\text{absorbed fraction from dosing medium used in toxicity study}} \quad (\text{eq. 5-5})$$

A  $RBA_{\text{soil-sediment}}$  of 0.50 was adopted for dioxins and furans. This value was derived from data on the bioavailability of TCDD in soils from a range of studies selected and presented by USEPA (2010c) in their *Final Report on Bioavailability of Dioxins and Dioxin Like Compounds in Soil*. The mean bioavailability of TCDD from soil in six studies presented by USEPA was 0.23 (i.e., 23 percent). This value was divided by the assumed absorbed fraction of 0.50 (i.e., 50 percent) used in establishing toxicity criteria for DLCs adopted for this BHHRA (JECFA 2002). The resulting  $RBA_{\text{soil-sediment}}$  was 0.50. Given differences in the

behavior of different DLCs in the environment, there is some uncertainty associated with the application of a value based on TCDD to all DLCs. These uncertainties are discussed in the uncertainty evaluation of the risk characterization.

A  $RBA_{\text{soil-sediment}}$  of 0.50 was also adopted for arsenic. This value was based on the findings of two meta-analyses (USEPA 2010e, Roberts et al. 2007) that reported ranges of bioavailability in soil from 0.05 to 0.31 and from 0.10 to 0.61, respectively. The absorbed fraction from drinking water, which is the dosing medium in the study that provides the basis for the toxicity criteria for inorganic arsenic used for this BHHRA, was assumed to be 1. A more complete discussion of the findings of these meta-analyses is provided in the EAM (Appendix A).

A  $RBA_{\text{soil-sediment}}$  for all other COPCHs was conservatively assumed to be 1.0. Additionally, the relative bioavailability from tissue ingestion ( $RBA_{\text{tissue}}$ ) was assumed as 1.0 for all COPCHs.

#### *Dermal Absorption Factor for Soil and Sediment*

The dermal absorption factor represents the proportion of a chemical that is absorbed across the skin from the soil and/or sediment matrix once it has been contacted. Skin permeability is related to the solubility or strength of binding of the chemical in the soil or sediment matrix compared to the skin's stratum corneum and the degree to which the chemical can penetrate the stratum corneum to enter the bloodstream. Therefore, dermal absorption is dependent on the properties of the chemical itself, as well as on external factors including the physical properties of the soil or sediment matrix (e.g., particle size, organic carbon content) and the conditions of the skin (e.g., skin condition, moisture content). Data with which to characterize dermal absorption of chemicals from sediment is not readily available and dermal absorption of chemicals from soil and sediment matrices will differ to some degree. In the absence of sediment-specific information, however, USEPA (2004) supports the application of factors derived for soil to sediment.

Dermal absorption factors for dioxins and furans, arsenic, PCBs, and bis(2-ethylhexyl)phthalate (BEHP) were obtained from USEPA (2004). Those for chromium, mercury, and nickel were obtained from the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment's (OEHHA) *Technical Support*

*Document for Exposure Assessment and Stochastic Analysis, Draft* (CalEPA 2011).

Following USEPA (2004) guidance, in the absence of available data for copper and zinc, a conservative dermal absorption factor of 1.0 was assumed for these COPCHs. The dermal absorption factors applied in this BHHRA are presented in Table 5-7.

#### *Chemical Reduction Due to Preparation and Cooking*

It is well recognized that preparation and cooking may reduce chemical concentrations in fish tissues, particularly for lipophilic compounds such as dioxins, furans, and PCBs (USEPA 2000b, 2002b; Wilson et al. 1998). These changes are dependent on a number of factors including the lipophilicity of the compound, the type of fish, and the parts of the fish consumed.

For the deterministic CTE and RME evaluations, a cooking loss of 0 (zero percent loss) was conservatively assumed for PCBs and dioxins. In line with the EAM (Appendix A), the impact of applying a cooking loss of 0.25 (25 percent loss) was explored in the uncertainty evaluation for the risk characterization and available information on distributions of cooking loss were considered in the PRA. Following the submittal of the EAM in May 2012, a meta-analysis was published that provided a critical review of the available data on cooking loss factors for lipophilic compounds (AECOM 2012). The findings of this study are also discussed in the uncertainty evaluation.

#### *5.1.2.3 Probabilistic Exposure Evaluation*

A probabilistic exposure evaluation was completed for scenarios that met one or more of the following thresholds (Figure 1-4):

- (1) The cumulative estimated exposure from all pathways resulted in an incremental cancer risk  $>1 \times 10^{-4}$
- (2) The cumulative estimated exposure from all pathways resulted in a total endpoint-specific noncancer HI  $>1$
- (3) The cumulative estimated exposure from all pathways resulted in a dioxin cancer HI  $>1$ .

The PRA focused on chemicals that were identified as potential risk drivers. Risk drivers were defined as COPCHs that contributed at least five percent of overall risk or hazard across all exposure pathways that made up the selected scenario, and contributed more than 5 percent to the pathway-specific risk or hazard associated with the medium of interest. Both potential exposures within USEPA's Preliminary Site Perimeter and background exposures were evaluated.

Based on the thresholds described above, a PRA was completed for a hypothetical young child fisher and a hypothetical young child recreational visitor. A single model was used to evaluate all hypothetical fishers (i.e., recreational and subsistence). The selection of these receptor groups, as well as the specific scenarios evaluated, are described further in Section 5.2.3.3 of the risk characterization. The general methods, EPCs, and exposure parameters used in the PRA are presented below, with supporting materials provided in Appendix G.

#### **5.1.2.4      *General Methods***

Probabilistic analyses were completed using Oracle® Crystal Ball software (Gentry et al. 2005). Crystal Ball employs Monte Carlo analysis, a commonly used probabilistic numerical technique where the uncertainty and variability in exposure and resulting hazard/risk estimates are characterized by developing distributions that present the full range of potential exposures.

For the PRA probability distributions were assigned to select exposure parameters to yield an output probability distribution for the exposure estimate rather than a single estimate. A probability distribution is a mathematical function that describes the values and the associated probabilities for a given parameter. For example, there are a wide range of body weights within the human population for a given age group, and the probability distribution for body weight is described as lognormal, which means that it is best represented as a bell-shaped curve with a long tail to the right. The shape of the curve represents the fraction of the population characterized by each body weight, with most individuals clustered together around a fairly limited range of body weights, but with a small number of individuals with a wide range of higher body weights represented by the long tail.

For this evaluation, a 1-dimensional probabilistic analysis, which focused on variability in exposure but did not quantify uncertainties, was completed. The distinction between variability and uncertainty is an important one. Exposure factors vary within the population (e.g., a wide range of fish ingestion rates, exposure durations, body weights), and they can also be uncertain because of a lack of or limited information available about a specific parameter. Parameter variability is an inherent reflection of the natural variation within a population. Uncertainty represents limited or lack of perfect knowledge about specific variables, models, or other factors. Uncertainty can be reduced through further study, measurements, etc., whereas variability cannot. Although the explicit focus of this PRA was to model variability in exposure (and resulting potential risk), all of the distributions used for the PRA inherently also include varying amounts of uncertainty that exist in the exposure parameters.

To develop the output distribution for exposure, the exposure estimate for a receptor-COPCH pair was repeatedly calculated by Crystal Ball. Each iteration of the exposure model used different combinations of parameter values, as determined by random sampling of the probability distributions for those input parameters that were treated probabilistically (USEPA 2001). For each scenario evaluated, 10,000 simulations were run. A quantitative sensitivity analysis was also performed to test the effect of certain input parameter distributions on the exposure outcome.

#### **5.1.2.4.1 Exposure Point Concentrations**

For the PRA, EPCs were established for COPCHs that were identified as potential risk drivers in the scenarios selected for analysis. Specifically, these were dioxins and furans in sediments, soils, and edible tissues; PCBs in all edible tissues; and mercury in catfish fillet. The EPCs were developed as distributions based on the best-fit distribution of the data. For datasets with sample sizes less than 15, the upper-bound for the EPCs for the PRA was established as the mean value plus three standard deviations. For datasets with sample sizes equal to or greater than 15, the maximum concentration in the distribution was established as the maximum detected concentration. This sample size-dependent approach was used because the larger datasets allowed for more complete characterization of the conditions

being studied. The lower bound for all distributions was set as a minimum concentration of zero.

#### **5.1.2.4.2 Exposure Parameters**

A brief description of the exposure parameters selected for the PRA is provided below. A complete discussion and supporting rationale for each parameter is included in Appendix G. Tables 5-8 and 5-9 provide a summary of the exposure parameters adopted for the PRA and show how they differ from those selected for the deterministic evaluation.

##### ***Common Parameters***

For the hypothetical young child receptor's exposure duration, a triangular distribution<sup>23</sup> with a minimum of 1 year, most likely value of 3.5 years, and maximum of 6 years was assumed. This distribution was based on best professional judgment with the maximum value set to the RME exposure duration used for the hypothetical young child in the deterministic evaluation. The averaging time for each iteration of the model was set equal to the randomly selected exposure duration for that iteration.

For body weight, a lognormal distribution with a mean of 17.27 kg and a standard deviation of 4.97 kg was used. This relationship was derived by Portier et al. (2007) for children ages 1 through 6 years, and is based on NHANES IV data. The distribution for body weight was bound at the lower and upper ends based on best professional judgment and using lower and upper percentiles of body weight for the defined population.

##### ***Parameters for Tissue Ingestion***

The assumed input distributions for the fish and shellfish consumption rates for young children were the empirical data collected during the Lavaca Bay (Alcoa 1998) survey upon which the fish and shellfish ingestion rates for the deterministic evaluation were based. It is noted that in this study a large percentage of children who consumed fish during the survey

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<sup>23</sup> A triangular distribution is a continuous probability distribution with a lower limit, an upper limit and a single modal (i.e., most likely) value. The selection of a value between the straight lines that connect the minimum and modal values and the maximum and modal values is defined by the probability between these two values. These distributions are used when one has information about the range of potential values and a reasonable estimate of the most likely value for that parameter.

period did not consume any shellfish. Because these individuals were fish consumers, the report on Lavaca Bay included zero values for shellfish ingestion rates for these individuals when calculating ingestion rates for shellfish consumers. The same approach was used for the PRA.

The fractions of total fish and shellfish consumed that were harvested from the within USEPA's Preliminary Site Perimeter are likely to vary substantially among individuals. For the PRA, these parameters were both set to a triangular distribution with a most likely value of 0.25, a minimum value of 0.01, and a maximum value of 1. The reported range was based on the findings from the Lavaca Bay study, which were also used in developing the deterministic parameter values for this term, as well as best professional judgment.

#### ***Parameters for Direct Contact***

The fraction of total intake that was soil versus sediment for each scenario was set to the point estimate that was adopted for the deterministic evaluation and so was not treated probabilistically. The fisher was assumed to be exposed 100 percent of the time to sediment, with no exposure to soils, whereas the recreational visitor was assumed to receive 50 percent of total daily exposure through soil and 50 percent through sediment.

For soil and sediment ingestion rates, a lognormal distribution with a geometric mean of 24 mg/day and geometric standard deviation of 4 mg/day was used. This distribution was based on a long-term estimate of soil ingestion developed from a tracer-element study of 64 children from Anaconda, Montana, and was consistent with other distributions established in the literature (Stanek and Calabrese 2001). A high-end ingestion rate of 1,000 mg/day recommended by USEPA (2011a) for pica behavior was applied as the maximum rate. A minimum ingestion rate of 0 mg/day was used to avoid the possibility of negative ingestion rates.

The exposed surface area for the hypothetical young child receptors was calculated as the product of the total surface area of an individual and the percent of surface area exposed, as follows:

$$SA_{\text{exposed}} = SA_{\text{total}} \times \% \text{ surface area exposed} \quad (\text{eq. 5-6})$$

Where:

$SA_{\text{exposed}}$  = exposed surface area

$SA_{\text{total}}$  = total surface area

The total surface area was calculated as a function of the body weight using the relationship established by Burmaster (1997). The factor for percent surface area exposed was modeled as a range, representing various combinations of the arms, legs, and feet exposed. The factor was assigned a triangular distribution with the most likely value equal to the percentage of total surface area for face, forearms, hands, lower legs, and feet. The minimum value assumed that only the face, forearms, and hands were exposed, while the maximum value assumed that the face, entire arm, hands, entire leg, and feet were exposed. Surface area data were obtained from USEPA (2011a).

For the sediment adherence factor, a uniform distribution<sup>24</sup> with a minimum of 0.09 mg/cm<sup>2</sup> and maximum of 3.6 mg/cm<sup>2</sup> was used. The maximum value assumed was based on body part-specific adherence factors from a study of children playing in tidal flats, weighted to the most likely exposed body parts discussed above. This value was also used in the deterministic evaluation for this BHHRA. In the absence of specific data on adherence to sediments with characteristics similar to those within USEPA's Preliminary Site Perimeter (i.e., fine grained), a minimum value was selected from a study that measured soil adherence in children. In this instance, the range of values represented both variability and uncertainty in the adherence of sediment that could occur. A distribution for the soil adherence factor was not developed. For the PRA, this parameter was treated as a point estimate of 0.09 mg/cm<sup>2</sup> and was the same value that was selected for the deterministic evaluation.

Two distributions of potential exposure frequencies for direct contact with soils and sediments were established—one for the fisher and one for the recreational visitor. The selected values were centered around the factors adopted for the deterministic risk

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<sup>24</sup> A uniform distribution is a straight line, defined by a minimum and maximum value, with an equal probability of selecting any value between the minimum and maximum values. It is used when a reasonable estimate of the range of likely values can be made, but has little information on the probabilities of values between the minimum and maximum.

calculation and were developed using best professional judgment. For the potential young fisher, a triangular distribution with a most likely value of 13 days/year, a minimum of 1 day/year, and a maximum of 156 days/year was adopted. For the potential recreational visitor, a triangular distribution with a most likely value of 52 days/year, a minimum of 1 day/year, and a maximum value of 156 days/year was adopted.

The distribution for fractional intake of soils and sediments that is related to potential exposures within the area of study was centered around the values assumed for the deterministic evaluation. For the hypothetical young child recreational visitor, a triangular distribution with a most likely value of 0.5, and minimum and maximum values of 0.1 and 1.0, respectively, was adopted. It is possible that a fisher would spend a greater duration of time in locations within the area of study on any given day compared to a recreational visitor. Therefore, for the PRA, a higher fractional intake was adopted for the fisher than for the visitor. For this receptor, a triangular distribution with a most likely and maximum value of 1.0 and a minimum value of 0.5 was assumed.

### ***Chemical Specific Factors***

Potential risk-driving COPCHs identified in the deterministic risk assessment were carried forward for further evaluation in the PRA. These were determined to be dioxins and furans in sediment, all tissue types, and in soil; PCBs in all tissue types; and mercury in catfish only. For the PRA, distributions for chemical reduction due to preparation and cooking were developed for dioxins, furans, and total PCBs. These distributions were based on a meta-analysis of cooking loss studies and findings completed by AECOM (2012). This meta-analysis identified studies, completed in a variety of tissue types, and applied a range of preparation and cooking methods, with sufficient data for quantitative analysis to determine the range and midpoint of cooking loss for dioxins and PCBs. The analysis focused on studies that used a relevant and appropriate experimental method and presented changes in raw and cooked fish tissue COPC levels on a mass basis. This is because a comparison of concentrations in raw and cooked fish alone neglects the change in tissue mass that occurs with cooking, which is often significant. The authors reported percentiles and statistics for cooking loss for dioxins and furans and PCBs. These were used to develop distributions for the cooking loss term for the PRA. The complete distributions are described in detail in Appendix G.

The loss parameters were applied to catfish fillet only and not to clams or crabs. No data on chemical reduction due to preparation and cooking specific to shellfish could be located. Clam tissue analyzed from within USEPA's Preliminary Site Perimeter had a substantially lower percent lipid than most finfish and techniques used for preparing and cooking shellfish differ from those used for finfish. As a result, the application of a loss factor based on cooking loss in finfish was not considered appropriate for shellfish. Therefore for the PRA, the cooking loss for shellfish ingestion was conservatively estimated at 0 percent.

For the oral  $RBA_{\text{soil-sediment}}$  for dioxins and furans, a lognormal distribution with a geometric mean value of 0.6 and standard deviation of 0.28, with minimum and maximum values of 0 and 1.0, respectively, was assumed. This distribution was developed using the studies presented by USEPA's (2010c) *Final Report on Bioavailability of Dioxins and Dioxin Like Compounds*. For the dermal absorption factor for soil/sediment ( $ABS_{\text{d soil-sediment}}$ ) for dioxins and furans a uniform distribution with a minimum value of 0.01 and a maximum value of 0.03 was adopted. This distribution was based on USEPA (2004) and studies published by Roy et al. (2008) and Shu et al. (1988).

## 5.2 Risk Characterization

Risk characterization is the final step in the risk assessment process. In this step, information from previous steps of the risk assessment is synthesized to provide an overall assessment of potential risks associated with the area being studied. The goal of risk characterization is to present and interpret the key findings of the risk assessment, along with their limitations and uncertainties, for use in risk management decision-making.

Cancer and noncancer hazards and cancer risks were quantified by combining the intakes estimated in the exposure assessment with the toxicological criteria compiled in the toxicity assessment to yield numerical estimates of potential health risk for specific receptor types under hypothetical exposure scenarios. A general description of the methods used for combining estimates of exposure and toxicological criteria and interpreting the resulting metrics is presented below. This is followed by the results for the risk characterization for this BHHRA for the area north of I-10 and aquatic environment.

### 5.2.1 General Methods for Risk Characterization

Three categories of potential health effects were evaluated for this BHHRA: cancer risk, noncancer hazard, and dioxin cancer hazard. The general methods for calculating each is described below.

#### 5.2.1.1 Cancer Risk

For all carcinogenic COPCHs other than dioxins and furans, cancer risk estimates were derived using standard risk assessment methods that estimate the incremental probability that an individual described by hypothetical exposure scenarios might develop cancer during his or her lifetime as a result of exposure to COPCs in the area under study. The term “incremental” reflects the fact that the calculated risk associated with any exposures in the area under study is in addition to the background risk of cancer experienced by all individuals in the course of daily life; that is, any risks associated with any exposures in the area under study are considered to be an incremental increase in the probability of developing cancer in addition to the background probability that an individual might develop cancer during his or her lifetime.

Excess incremental lifetime cancer risks were calculated as the product of the estimated exposure (i.e., LADD) and the expression of the carcinogenic potency of chemicals (e.g., cancer slope factor [CSF]). Excess incremental lifetime cancer risk from oral and dermal exposures was calculated using the following equation:

$$\text{Cancer Risk}(\text{unitless}) = \text{LADD} \times \text{CSF} \quad (\text{eq. 5-7})$$

Where:

LADD	=	lifetime average daily dose of the chemical via the specified exposure route (mg/kg-day)
CSF	=	cancer slope factor (kg-day/mg).

For each hypothetical receptor and exposure scenario, incremental cancer risks were summed across all the exposure pathways for each chemical and then across chemicals to estimate overall incremental cancer risk.

Both federal and state regulatory agencies define what they consider to be an acceptable level of incremental cancer risk associated with exposure to chemicals in environmental media. USEPA considers  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$  the target range for excess cancer risk (USEPA 1990).

The potential for cancer from exposure to dioxins and furans was evaluated as “dioxin cancer hazard.” This process is described in Section 5.2.1.3 below.

#### 5.2.1.2 Noncancer Hazard

Noncancer health risks are termed hazards. When an HI exceeds 1, this indicates that under the hypothetical exposure scenario evaluated, there is some potential for adverse health effects to occur as a result of chemical exposures assumed to have occurred in the area under study based on the hypothetical receptor and exposure scenario. To evaluate noncancer hazards, the ratio of the exposure term (i.e., average daily dose) to the corresponding noncancer toxicity reference value (i.e., RfD) is calculated. The HQ is calculated for each exposure route using the following equation:

$$HQ(\text{unitless}) = \frac{ADD}{RfD} \quad (\text{eq. 5-8})$$

Where:

ADD = average daily dose of the chemical via the specified exposure route  
(mg/kg-day)

RfD = reference dose (mg/kg-day).

To evaluate the effect of exposure via multiple exposure routes for each receptor, the route-specific HQs are summed for each COPCH to determine a noncancer HI using the following formula:

$$HI(\text{unitless}) = HQ_1 + HQ_2 + \dots + HQ_i \quad (\text{eq. 5-9})$$

Where:

HI = hazard index

HQ = hazard quotient for a specified exposure route (unitless).

Once the HQs for individual COPCHs were summed for an individual receptor to derive a COPCH-specific HI, the COPCH-specific HIs were summed to derive a total HI for that exposure scenario.

HIs that are calculated for multiple chemicals as described above are likely to overstate risk if the RfDs for the chemicals are based on adverse effects on different target organs. This is because the noncancer health hazards associated with chemicals that affect different target organs or have different health effects are not likely to be additive. For this BHHRA, following USEPA guidance (1989) in the case that the total HI for a receptor exceeded 1 for all COPCHs combined, separate hazard indices for group of COPCHs that affect the same target organ or endpoint were estimated. These effect-specific HIs provide a more accurate indication of whether there is potential for a specific adverse health effect to occur for a specific hypothetical receptor and exposure scenario.

If the resulting multi-chemical or effect-specific HI is less than 1 for a given hypothetical exposure scenario, then no adverse health effects are expected to occur (USEPA 1989). If the HI is greater than 1, then further risk evaluation may be appropriate. However, HIs greater than 1 do not necessarily mean that any actual adverse health effects would be observed in a receptor population under the hypothetical exposure scenario that provides the basis for the exposure estimate. A substantial margin of safety has been incorporated into the RfDs developed for the COPCs. For these chemicals, adverse health effects may not occur even if the HI is much larger than 1. The ratio is not a measure of probability that adverse health effects will occur. That is, the level of concern for health effects to occur does not necessarily increase linearly as the RfD is approached or exceeded (USEPA 1989).

### **5.2.1.3 Dioxin Cancer Hazard**

As discussed in the TESM (Appendix B), the scientific literature indicates that dioxins act via a non-linear mode of action, which suggests that a threshold dose must be reached before a carcinogenic effect can occur (Integral 2012b). Consistent with this concept, the carcinogenic potential for TEQ<sub>DF</sub> was estimated for this BHHRA using a hazard metric like that described for noncancer hazards above. Cancer hazards due to TEQ<sub>DF</sub> were expressed as an HQ for a single potential exposure route and an HI when hazards from all potential exposure routes for a receptor were summed. Because cancer is a different toxic endpoint from the noncancer endpoints, the HIs for dioxin were not summed with noncancer hazards.

### **5.2.1.4 Age Groups and Exposure Durations**

Cancer risks, noncancer hazards, and dioxin cancer hazards were characterized for different age groups. As is customary in the practice of human health risk assessment, cancer risks for nonthreshold carcinogens were evaluated over a lifetime using the LADD as the intake metric. For this estimate, the intake for each individual age group was calculated and intakes for all relevant age groups were combined and summed to derive a total LADD; for the RME hypothetical recreational fisher, subsistence fisher, and recreational visitor, six years of exposure as a young child, 11 years of exposure as an older child, and 16 years of exposure as an adult were assumed and summed to estimate exposure for a total combined exposure period of 33 years. For the CTE hypothetical recreational fisher, subsistence fisher, and recreational fisher, only exposure to an adult was evaluated for the total assumed exposure duration of 33 years.

In contrast to cancer risks, noncancer and cancer hazards for threshold carcinogens are generally estimated separately for life stages for which differences in behavior and relative intake (per unit body weight) are exhibited. Because intake for noncancer hazards is estimated using an average daily dose rather than the LADD used to evaluate cancer risk, the life stage that results in the highest potential exposure for an individual will also exhibit the greatest potential hazard. For this BHHRA, noncancer hazards and dioxin cancer hazards were estimated for the age group that had the highest relative potential exposure of all age groups conceptualized for a given scenario. For all RME scenarios, this was the young child. A comparison of the potential pathway-specific RME doses for each age group is presented in

Table 5-10. These ratios were calculated using the exposure parameters presented in Table 5-6. CTE hazards were estimated for an adult.

### **5.2.2 Deterministic Risk Assessment**

This section presents the baseline deterministic risk results by potential receptor group. A summary of all estimated RME hazards and risks is provided in Table 5-11; a summary of estimated CTE hazards and risks is provided in Table 5-12. The full set of risk and hazard estimates are provided as Appendix H. Tables H-1 through H-14 present assumed exposures, and resulting estimated hazards and risks by exposure medium. Tables H-15 through H-42 present estimated hazards and risk by exposure scenario. Tables H-43 through H-54 show the contribution of each COPCH and each exposure pathway to overall risks and/or hazards for the hypothetical scenarios that resulted in excess cancer risk above  $1 \times 10^{-4}$  or hazards greater than 1. These relative contributions were used for identifying risk drivers.

#### **5.2.2.1 Hypothetical Recreational Fisher**

Potential exposure routes for hypothetical recreational fishers were assumed to include incidental ingestion and dermal contact with sediment and ingestion of fish or shellfish. Twelve hypothetical exposure scenarios were evaluated for this receptor group. These included direct contact exposure at one of four beach areas (A, B/C, D, or E) in combination with the ingestion of catfish fillet, crabs, or clams from the adjacent FCA evaluated for the particular type of tissue.

Table 5-13 presents a summary of estimated cumulative noncancer hazard, cancer risk, and dioxin cancer hazard for the hypothetical recreational fisher scenarios. The noncancer RME HIs ranged from 0.03 to 50, while the CTE HIs were all less than 1. Table 5-14 presents endpoint-specific HIs for all hypothetical recreational fishing scenarios that exhibited a HI greater than 1. Three scenarios with an overall HI greater than 1 did not exhibit any endpoint-specific HI greater than 1, including: 1) Scenario 1A - Direct contact with sediment at Beach Area A and ingestion of catfish from FCA 2/3; 2) Scenario 2A - Direct contact with sediment at Beach Area B/C and ingestion of catfish from FCA 2/3; and 3) Scenario 4A - Direct contact with sediment at Beach Area D and ingestion of catfish from FCA 1. The noncancer hazards associated with these hypothetical scenarios are not discussed further.

The only hypothetical recreational fisher scenarios that had endpoint-specific RME HIs greater than 1 were those that assumed potential direct contact with sediments at Beach Area E. For these scenarios, the vast majority of the estimated noncancer hazard was attributable to direct exposure to sediment (Appendix H). For hypothetical recreational fisher scenarios assuming exposure at Beach Area E and consumption of either crabs or clams, only the HI specific to reproductive/developmental endpoints exceeded 1, and TEQ<sub>DF</sub> intake contributed 99 percent of the estimated hazard. For hypothetical recreational fisher scenarios assuming exposures at Beach Area E and the consumption of catfish from FCA 2/3 (i.e., Scenario 3A), HIs specific to reproductive/developmental endpoints and immunotoxicity endpoints both exceeded 1 and were estimated at 40 and 2, respectively. For exposures assumed to occur under the conditions defined by this scenario, TEQ<sub>DF</sub> contributed 98 percent of the reproductive/developmental HI, and mercury contributed the remaining 2 percent. The HI specific to immunotoxicity was primarily influenced by PCBs in catfish (Appendix H).

Across all hypothetical recreational fisher scenarios, cumulative estimated RME cancer risks ranged from  $5 \times 10^{-7}$  to  $2 \times 10^{-5}$ . Cumulative estimated CTE cancer risks were more than an order of magnitude lower and ranged from  $2 \times 10^{-8}$  to  $7 \times 10^{-7}$  (Table 5-13).

TEQ<sub>DF</sub> cancer HIs were all less than 1 for hypothetical recreational fisher exposure scenarios assuming direct contact at Beach Area A, B/C, or D, and the consumption of catfish fillet, crabs, or clams from the adjacent FCA. For hypothetical recreational fisher scenarios that assume direct contact at Beach Area E and ingestion of catfish from FCA 2/3, crabs from FCA 2, or clams from FCA 2/3, the RME cancer HIs for TEQ<sub>DF</sub> were all 10. For these scenarios, assumed, direct contact with sediments contributed over 98 percent of the total hazard (Appendix H). The estimated CTE TEQ<sub>DF</sub> cancer HI was less than 1 for all hypothetical recreational fisher scenarios.

Overall, hypothetical recreational fisher scenarios that assumed direct contact at Beach Area E were the only scenarios that resulted in endpoint-specific noncancer HIs and TEQ<sub>DF</sub> cancer HIs greater than 1. No cumulative cancer risks for these scenarios exceeded the  $1 \times 10^{-4}$  threshold (Table 5-13). Direct contact assumed to occur at Beach Area E accounted for over 98 percent of the hazards for hypothetical recreational fisher scenarios. Assumed exposure

to TEQ<sub>DF</sub> contributed 98 percent of the estimated hazard for these direct pathways. For catfish consumers, PCBs in catfish, in combination with assumed direct exposure at Beach Area E, contributed to hazards in Scenario 3A (Table 5-14).

It is important to note when considering the risk results, Beach Area E was capped as part of the TCRA, and that any potential direct contact exposure to sediments in this area are no longer possible under current, post-TCRA conditions. The implication of limiting exposure to the sediments present within the 1966 perimeter of the northern impoundments was evaluated in Appendix F, and discussed further in Section 5.2.3.2.

#### **5.2.2.2      *Hypothetical Subsistence Fisher***

The exposure pathways and scenarios that were evaluated for hypothetical subsistence fishers were identical to those evaluated for the hypothetical recreational fisher. The differences between the hypothetical subsistence and recreational fisher scenarios were the frequency and intensity with which each receptor group was assumed to be exposed to sediments in the area under study and the amount of finfish or shellfish tissue that each was assumed to consume. This second factor was a result of variations in the parameters incorporated for both the total ingestion rate assumed for finfish and shellfish and the fractional intake of finfish and shellfish that was assumed to come from the area under study. Because subsistence fishing is defined as a high-end exposure, no CTE risks or hazards were estimated for this potential receptor group.

As for the hypothetical recreational fisher, twelve separate exposure scenarios were assumed and evaluated for the hypothetical subsistence fisher. These included direct contact at one of each of the four beach areas in combination with the ingestion of catfish fillet, crabs, or clams from the appropriate, adjacent FCA.

Table 5-15 presents a summary of estimated cumulative noncancer hazards, cancer risks, and TEQ<sub>DF</sub> cancer hazards for the hypothetical subsistence fisher scenarios. Although overall hazards and risks were greater for the hypothetical subsistence fisher scenario than for the hypothetical recreational fisher scenario, similar trends in the relative risks associated with

the various exposure units and the contribution of specific COPCHS to overall hazards and risks were observed.

Across all hypothetical subsistence fisher scenarios evaluated, the overall noncancer RME HI ranged from 0.2 to 100 (Table 5-15). The noncancer HIs for these scenarios were 2 to 11 times greater than the RME HIs for the hypothetical recreational fisher scenarios, and more than an order of magnitude greater than the CTE HIs estimated for adults under the hypothetical recreational fisher scenario.

Table 5-16 presents endpoint-specific noncancer HIs for all hypothetical subsistence fisher scenarios with an overall HI greater than 1. As was the case for the scenarios evaluated for the recreational fisher, the greatest noncancer hazards were estimated for the hypothetical subsistence fisher scenarios that assumed direct contact with sediments at Beach Area E under the baseline condition (i.e., immediately prior to the TCRA). The reproductive/developmental-specific HI associated with the assumed direct contact at Beach Area E (Scenario 3A, Table 5-16) was 100 for subsistence fishers. Assumed direct contact with sediments alone at other beach areas did not result in overall noncancer HIs greater than 1 (Appendix H). Unlike the hypothetical recreational fisher, assumed consumption of fish and shellfish from certain FCAs in the subsistence fisher scenario, resulted in endpoint-specific noncancer HIs that were greater than 1 (e.g., Scenario 2A), even without direct contact with beach sediments. Noncancer hazards from the assumed ingestion of catfish from either FCA 2/3 or FCA 1 were largely influenced by TEQ<sub>DF</sub> (47 percent of overall hazard), PCBs (38 percent of overall hazard), and mercury (12 percent of overall hazard). Hazards from the assumed ingestion of clams from FCA 2 were largely influenced by TEQ<sub>DF</sub> (90 percent of overall hazard) and PCBs (9 percent of overall hazard) (Appendix H).

Across all hypothetical subsistence fisher scenarios, cumulative RME excess cancer risks ranged from  $3 \times 10^{-6}$  to  $1 \times 10^{-4}$  (Table 5-15) and, thus, fell within EPA's target risk range.

The TEQ<sub>DF</sub> cancer HI for hypothetical subsistence fisher Scenarios 3A, 3B, and 3C, all of which assumed direct contact with sediments in Beach Area E under the baseline condition, was 40 (Table 5-15). In addition, the hypothetical subsistence fisher scenarios that assumed direct contact with other beach areas and the consumption of catfish from FCA 2/3 or FCA 1

resulted in a TEQ<sub>DF</sub> cancer HI of 3. The TEQ<sub>DF</sub> cancer hazards for hypothetical subsistence fisher scenarios that assumed direct contact at Beach Area A, B/C, or D, and which assumed the ingestion of crabs or clams from the adjacent FCAs, were all less than 1.

#### **5.2.2.3 Hypothetical Recreational Visitor**

Exposure routes assumed for the hypothetical recreational visitor scenario included assumed incidental ingestion and dermal contact with a combination of soil and sediment. Four hypothetical exposure scenarios were evaluated for this receptor; these assumed direct contact with sediments at each of the four beach areas combined with direct contact with soils throughout the northern impoundments.

Table 5-17 presents a summary of cumulative noncancer hazards, cancer risks, and TEQ<sub>DF</sub> cancer hazards for the recreational visitor scenarios. Details on noncancer hazards are presented in Table 5-18.

The hypothetical recreational visitor scenario, which assumed baseline exposure via direct contact with sediments at Beach Area E and soils throughout the area north of I-10 (Scenario 3), resulted in the highest noncancer hazards, excess cancer risks, and TEQ<sub>DF</sub> cancer hazard. For this scenario, the overall RME noncancer HI was 60, and over 99 percent of that hazard was attributable to exposure to TEQ<sub>DF</sub> in sediments at Beach Area E (Appendix H). The CTE noncancer hazard was less than 1. For hypothetical recreational visitor scenarios assuming direct contact with sediments at Beach Area A, B/C, or D and soils throughout the northern impoundments, the resulting noncancer RME HIs were all less than 1.

Table 5-18 presents endpoint-specific HIs for hypothetical recreational visitor scenarios. The only hypothetical recreational visitor scenario that resulted in a RME noncancer HI greater than 1 was the scenario that assumed direct contact with sediments in Beach Area E and the soils in the impoundments north of I-10. The hazards associated with this scenario were largely attributed to reproductive/developmental endpoints, and the HI for this specific endpoint was equal to the overall HI at 60. No other endpoint-specific HIs were greater than 1 for this scenario.

For all hypothetical recreational visitor scenarios, cumulative RME cancer risks ranged from  $8 \times 10^{-7}$  to  $1 \times 10^{-5}$  (Table 5-17). Cumulative CTE cancer risks were more than an order of magnitude lower.

The hypothetical recreational visitor scenario that assumed direct contact with sediments at Beach Area E and soils north of I-10 was estimated to have a RME TEQ<sub>DF</sub> cancer HI of 20 (Table 5-17). The corresponding CTE TEQ<sub>DF</sub> cancer HI for this scenario was less than 1. As for the noncancer effects, over 99 percent of the cancer hazard was attributable to assumed exposure to sediments at Beach Area E. For hypothetical recreational visitors exposed to other beach areas, in combination with soils north of I-10, the RME and CTE cancer TEQ<sub>DF</sub> HIs were all less than 1.

### **5.2.3 Refined Analyses**

Consistent with the approach summarized in Figure 1-4, additional analyses were completed to further characterize risks and/or hazards estimated for the hypothetical exposure scenarios that met one or more of the following thresholds:

- (1) The cumulative estimated exposure from all pathways resulted in excess cancer risk  $>1 \times 10^{-4}$
- (2) The cumulative estimated exposure from all pathways resulted in a total endpoint-specific noncancer HI  $>1$
- (3) The cumulative estimated exposure from all pathways resulted in a dioxin cancer HI  $>1$ .

Although none of the scenarios included in the baseline deterministic evaluation resulted in an estimated cancer risk greater than  $1 \times 10^{-4}$ , certain hypothetical scenarios resulted in endpoint specific HIs greater than 1 or dioxin cancer HIs greater than 1. Table 5-19 presents a summary of these scenarios. The refined analyses for each selected scenario consisted of three evaluations: 1) an analysis and comparison of background hazards with the estimated deterministic hazards for the area under study, 2) an evaluation of post-TCRA hazards, and 3) a PRA of potential hazards.

### **5.2.3.1 Background Hazard Evaluation**

Background hazards for exposure routes that compose the scenarios selected for refined analysis (Table 5-19) were calculated using the same assumptions about frequency and duration of exposure to each medium as were used in the main analysis of risks for USEPA's Preliminary Site Perimeter. Resulting exposures, hazards, and risks were tabulated (Appendix I). These results were then compared to corresponding results of the deterministic baseline evaluation for the area under study. The background noncancer hazards and dioxin cancer hazards are provided in Appendix I.

Estimated background RME and CTE noncancer hazards and dioxin cancer hazards for hypothetical recreational fishers, subsistence fishers, and recreational visitors are provided in Tables 5-20 and 5-21, respectively. To compare estimated baseline and background exposures, the RME noncancer hazard and dioxin cancer hazard endpoints were emphasized because these were the only endpoints for which the RME HIs in the baseline deterministic evaluation exceeded the target of 1.

Using background concentrations, the hypothetical subsistence fisher scenario that assumed the consumption of catfish was the only scenario that resulted in noncancer HI greater than 1 (Table 5-20). While the risks for the area under study were higher than background risks, it is important to note that background conditions resulted in a noncancer HI of 10 under this scenario. It is also useful to compare the estimated hazards that result from estimated exposure to each individual medium, so that the importance of each medium, and its contribution to risks for the area under study, relative to background and under baseline conditions, can be better understood.

Below, the absolute differences in assumed exposures and resulting hazards for the area under study and background are presented for each individual exposure medium, but are not presented for each receptor type. This is because this relative difference is the same for all scenarios. For example, if exposure to unit 1 under the hypothetical recreational fisher scenario resulted in twice the hazard estimated for this scenario in unit 2, then the same relative difference in exposure and risk was also true for the hypothetical subsistence fisher scenario evaluated in unit 1 versus unit 2.

#### 5.2.3.1.1 Direct Contact with Sediment

The endpoint-specific RME noncancer HIs and the cancer TEQ<sub>DF</sub> HIs for baseline exposure via direct contact with sediments at Beach Area E were greater than 1 for all hypothetical scenarios evaluated (Tables 5-19). For the hypothetical recreational fisher scenario with assumed exposure via direct contact at Beach Area E, the RME noncancer TEQ<sub>DF</sub> HI was 50 (ingestion and dermal contact combined) and the RME cancer TEQ<sub>DF</sub> HI was 10. More than 98 percent of the total noncancer hazard was attributable to TEQ<sub>DF</sub> (Table 5-11).

Hazards associated with dioxins and furans in background shoreline sediments were substantially lower (Table 5-20). Under identical exposure conditions for the hypothetical recreational fisher scenario identified above, but using background sediment concentrations, the RME noncancer TEQ<sub>DF</sub> HI was only 0.02, and the RME TEQ<sub>DF</sub> cancer HI was 0.0006 (Table 5-20). Therefore, risks for the hypothetical recreational fisher scenario, when assumed exposures included contact with beach sediment in background areas, were less than 1 percent of those calculated for assumed direct contact with sediments at Beach Area E under this scenario.

The RME noncancer TEQ<sub>DF</sub> HI for the hypothetical recreational fisher scenario, including exposure to sediments in other beach areas on the Site (i.e., Beach Area A, B/C, or D) ranged from 0.01 (for Beach Area A) to 0.07 (for Beach Area B/C). These were comparable to the estimated background risks. The RME cancer TEQ<sub>DF</sub> HIs for direct exposure to sediments in these beach areas (excluding Beach Area E), which ranged from 0.0005 to 0.002, were also comparable to background HIs (i.e., range of TEQ<sub>DF</sub> HIs of 0.0006 to 0.002).

Based on this analysis, it appears that potential risks due to direct contact with sediment in all areas except Beach Area E, were comparable to background risks. Potential risks in Beach Area E, under the baseline condition (i.e., immediately prior to the TCRA), exceeded background risks.

#### 5.2.3.1.2 Catfish Ingestion

Assumed ingestion of catfish from the area under study resulted in RME noncancer HIs that were greater than 1 for all fishing scenarios; the cancer TEQ<sub>DF</sub> HIs were greater than 1 for

only the hypothetical subsistence fisher scenario. Figure 5-6 shows RME noncancer HQs, by COPCH, for assumed consumption of catfish from FCA 2/3, FCA 1, and background for both the hypothetical recreational and subsistence fisher scenarios. TEQDF, PCBs, and mercury were the largest contributors to total noncancer hazards associated with assumed consumption of catfish at the area under study (Figure 5-6).

For TEQDF and PCBs, the estimated hazards resulting from ingestion of catfish from FCA 1 and FCA 2/3 were greater than the hazard associated with ingestion of catfish containing background levels of these COPCHs. It is important to note, however, that 41 to 42 percent of the baseline hazard attributed to TEQDF, and 55 to 60 percent of baseline hazard associated with PCBs were also present under background conditions. Hazards associated with exposure to methylmercury in catfish fillets were higher for background than for FCA 2/3 and were comparable to background for FCA 1.

This analysis indicates that while risks associated with the assumed consumption of catfish from the area under study were higher than background risks, background levels of TEQDF and PCBs contributed substantially to total risk estimates. For mercury, the estimated background risks were similar to or exceeded the risks associated with the area under study, indicating that the area under study is not contributing additional risks for this COPCH.

#### **5.2.3.1.3 Ingestion of Clams**

Assumed consumption of clams from FCA 2 resulted in RME endpoint-specific noncancer HIs that exceeded 1 for the hypothetical subsistence fisher scenario. When combined with other exposure pathways, the consumption of clams contributed to cumulative noncancer hazards that were greater than 1 for the hypothetical recreational fisher scenario. (As discussed previously, the vast majority of the noncancer hazard under this scenario was from assumed direct contact with sediment in Beach Area E [Table 5-11]). Assumed consumption of clams from FCA 2 also contributed to dioxin cancer hazards that were greater than 1 when all exposure pathways were summed for both the hypothetical recreational and subsistence fisher scenarios. Figure 5-7 presents noncancer HQs, by COPCH, for consumption of clams, calculated using COPCH concentrations for exposure units within USEPA's Preliminary Site Perimeter and background.

Although no cumulative hazards for scenarios that assumed consumption of clams from FCA 1/3 resulted in a HI greater than 1, the noncancer HQs that were estimated from concentrations in clams from this FCA were included to provide additional perspective on the impact of background levels. As illustrated in Figure 5-7, the contribution of clam consumption to the cumulative hazard quotient for the hypothetical recreational and subsistence fisher scenarios was much larger for FCA 2 than for either FCA 1/3 or background (Figure 5-7), and tissue concentrations of TEQ<sub>DF</sub> in clam were the largest driver for these differences.

#### **5.2.3.1.4 Ingestion of Crabs and Direct Contact with Soil**

Ingestion of crabs and direct contact with soils were minor contributors to scenarios that resulted in HIs greater than 1. Although the assumed consumption of crabs from FCA 1 contributed to cumulative TEQ<sub>DF</sub> noncancer and cancer HIs that exceeded 1 for hypothetical Scenario 3C (i.e., direct contact with sediments at Beach Area E and the consumption of crab from FCA 1), consumption of crab itself, did not result in a HI greater than 1 for any scenario evaluated, and it contributed less than 1 percent of the total HI reported for Scenario 3C (Appendix H). Similarly, direct contact with soils in the area north of I-10 contributed less than one percent to the cumulative noncancer and dioxin cancer HIs for Scenario 3 (i.e., Scenario 3—Direct contact with sediments at Beach Area E and soils north of I-10). Given the minor contributions of crab ingestion and direct contact with soil to hazard estimates for the area under study, a discussion of background hazards associated with these exposure pathways is not presented.

#### **5.2.3.1.5 Summary of Comparisons of Baseline Risks to Background**

Background concentrations of certain COPCs contributed substantially to potential risks associated with certain media. Hypothetical baseline exposure to sediments in Beach Area E resulted in potential risks that exceeded background levels, but the risks estimated for sediments in the other beach areas within USEPA's Preliminary Site Perimeter (Beach Areas A, B/C, and D), were consistent with risks calculated using background concentrations, indicating that potential risks due to sediments in those areas are not elevated above background levels.

Assumed ingestion of catfish from the area under study resulted in higher potential risks than ingestion of catfish from background locations. However, background concentrations contributed substantially to total risks, providing roughly one-half of the total risks estimated for PCBs and TEQ<sub>DF</sub>. In addition, the background analysis indicated that all of the risks associated with mercury in catfish were likely due to background concentrations of mercury.

While the assumed consumption of clams did not contribute substantially to total risks, the analysis of background indicated that risks associated with the consumption of clams from FCA 2 exceeded background risks and resulted in a pathway-specific HQ greater than one for the hypothetical subsistence fisher scenario. Risks associated with assumed consumption of clams from FCA 1/3 were slightly higher than background risks, but contributed only marginally to the cumulative hazard for both hypothetical recreational and subsistence fishers in comparison to assumed direct exposure to sediment at Beach Area E.

Direct contact with soils in the area of study and ingestion of crab did not contribute substantially to total estimated risks for those hypothetical scenarios that assumed these routes of exposure and exceeded a HI of 1. Therefore, an analysis of background risks was not conducted for these media.

#### **5.2.3.2 Post-TCRA Evaluation**

An evaluation of post-TCRA noncancer hazards and dioxin cancer hazards was completed for the scenarios outlined in Table 5-19. The post-TCRA exposures considered for the sediments and soils reflect the limited access of individuals to large portions of the area within USEPA's Preliminary Site Perimeter, as a result of the implementation of the TCRA (Figure 1-3). As described in Appendix F, the post-TCRA evaluation also incorporates model-estimated reductions in the concentrations of dioxins and furans in catfish tissue and the exclusion of clam tissue from Transect 3 from the dataset used to calculate clam EPCs; for crab, no change in tissue concentrations from baseline conditions was assumed. Both the hazards associated with the post-TCRA condition, as well as a measure of the reduction in hazard resulting from implementation of the TCRA were evaluated. Hazard reduction for the area under study was defined as the percentage of such hazard (i.e., indicated as baseline hazard above

background) that was removed under the post-TCRA condition relative to the baseline condition. A complete presentation of methods and results for the post-TCRA analysis, including the calculation of EPCs and the post-TCRA hazard characterization, is provided in Appendix F. The results of this evaluation are summarized briefly below.

Under the post-TCRA condition, the RME noncancer  $TEQ_{DF}$  HI is less than 1 for all hypothetical recreational fisher and recreational visitor scenarios evaluated. For the hypothetical subsistence fisher, only exposure scenarios that assumed consumption of catfish from FCA 2/3 in combination with direct contact to sediments had a RME  $TEQ_{DF}$  noncancer HI that exceeds 1 in the post-TCRA analysis. The RME noncancer  $TEQ_{DF}$  HI is 6 for these scenarios.

For all hypothetical scenarios (as well as for individual pathways) evaluated for the baseline risk assessment, the noncancer  $TEQ_{DF}$  HI was 3.3 fold higher than the cancer  $TEQ_{DF}$  HI. This is because the noncancer hazard and cancer hazard predictions used the same estimates of exposure and relied only on different toxicological criteria (i.e., the noncancer RfD of 0.7 mg/kg-day, and a cancer threshold TDI of 2.3 mg/kg-day). Under the post-TCRA condition, for all of the hypothetical recreational fisher and the recreational visitor scenarios evaluated, the cancer  $TEQ_{DF}$  HI is less than 1. For the hypothetical subsistence fisher, only exposure scenarios that assumed the consumption of catfish from FCA 2/3 in combination with direct contact to sediment has a post-TCRA RME cancer  $TEQ_{DF}$  HI greater than 1. The RME noncancer  $TEQ_{DF}$  HI is 2 for these scenarios under post-TCRA conditions.

The greatest reduction of hazards for both cancer and noncancer effects is for scenarios that assumed direct exposure to Beach Area E under baseline conditions. This is because the vast majority of  $TEQ_{DF}$  exposure and hazard for these scenarios is related to assumed direct contact rather than to the ingestion of fish or shellfish, and because exposure to sediment in this area is completely restricted under the post-TCRA condition. For these scenarios, the reduction in hazards related to the area under study resulting from the implementation of the TCRA range from 84 to 100 percent. For baseline exposure scenarios that assumed direct contact with sediments at Beach Area A, B/C, or D and the consumption of tissue from the adjacent FCA, the reduction in hazard ranges from 65 to 86 percent. A discussion of the uncertainties in this analysis is presented in Appendix F.

### **5.2.3.3 Probabilistic Risk Assessment**

The results of the PRA provide insight into the variability of exposures and risks that may occur within the potentially exposed population. Exposure and resulting noncancer hazards and dioxin cancer hazards for hypothetical young child fishers and young child recreational visitors were modeled in the PRA because this was the only age group for which HIs exceeded 1. The specific scenarios modeled are shown in Table 5-19. Only COPCHs defined as risk drivers were included in the PRA. These were TEQ<sub>DF</sub> in sediment, tissues, and soils, PCBs in all tissue types, and methylmercury in catfish. The probability distributions used to model exposures in the PRA were discussed above in Section 5.1.2.2.1 and are presented in Appendix G.

Monte Carlo simulations were completed using Oracle® Crystal Ball software (Gentry et al. 2005). In order to investigate the numerical stability of the Monte Carlo calculations, 10 independent trials, each of 10,000 iterations, were run for two of the hypothetical receptor exposure scenarios being evaluated as part of the PRA (i.e., Scenarios 1A and 3A, chosen to represent one low-end and one high-end hazard scenario, respectively). The coefficients of variation<sup>25</sup> were 0.9–1.4 percent for the 50th percentile cancer and noncancer hazards and 1.6–2.4 percent for the 95th percentile cancer and noncancer hazards. On the basis of the relatively low variability indicated by these small coefficients of variation, 10,000 iterations were considered sufficient to produce stable numerical results.

For each of the hypothetical scenarios evaluated, the 50th, 90th, and 95th percentiles of the resulting output hazard distributions were summarized. The 50th percentile hazards represent estimates for individuals exposed under assumed average (or typical) conditions, while the 90th and 95th percentile hazards represent estimates for the individuals in the population assumed to be highly exposed. Table 5-22 presents the PRA results for noncancer hazards and Table 5-23 presents the PRA results for dioxin cancer hazards. The results from the deterministic evaluations are included in these two tables for comparison.

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<sup>25</sup> The coefficient of variation is the standard deviation divided by the mean.

#### 5.2.3.3.1 Hypothetical Young Child Fisher

The model developed for each exposure scenario for the hypothetical young child fisher scenario included a range of exposures that was inclusive of the behaviors of both hypothetical recreational and subsistence fishing populations. The models were set up in this manner so that the impact of true variability in behaviors and patterns of exposure across the entire fisher population could be captured and explored. While the labels “recreational fisher” and “subsistence fisher” imply that there are two completely separate populations that have different and unique characteristics, it is appropriate to assume that there would be substantial overlap in the behaviors of average- and high-consuming individuals. For example, it is possible that some fishers assumed to consume large amounts of finfish on an annual basis only obtain a small portion of their total catch from within USEPA’s Preliminary Site Perimeter, while other high consumers obtain most of their fish from this area. At the same time, there may be individuals assumed to consume at high rates but only fish within USEPA’s Preliminary Site Perimeter during a single season while others fish there for many years. The same variations in behavior occur within the fisher population that consumes fish at more typical rates. Therefore, while some of the individuals modeled in the PRA may have behaviors that are similar to the behaviors modeled in the deterministic analysis for the hypothetical recreational fisher, and some may resemble the deterministic analysis for the hypothetical subsistence fisher, others will have characteristics that more closely resemble a combination of these populations. The PRA analysis for the hypothetical young child fisher was developed to capture the highly variable behaviors within the entire population of fishers. Details on the exposure probability distributions developed to represent the full range of potential fishing behaviors within a single model are provided in Appendix G.

When viewing the PRA results for the hypothetical young child fisher, the 50th percentile estimates represent hazards an individuals who may exhibit a combination of typical or average behaviors. The 90th and 95th percentiles characterize hazards for individuals who may participate in fishing activities that lead to high-end exposures.

As was seen in the deterministic evaluation, the PRA indicated that hypothetical scenarios that assumed direct contact with sediments at Beach Area E (in combination with the consumption of tissue from the adjacent FCA), exhibited significantly higher noncancer and

dioxin cancer hazards than scenarios that assumed direct contact with sediments at Beach Area A, B/C, or D. The types of assumed exposures that contributed most significantly to the intake of COPCHs differed for these two subsets of scenarios. While direct contact pathways contributed the majority of the estimated exposure for scenarios that involved fishers at Beach Area E, the assumed consumption of finfish or shellfish was the most significant exposure route for all other scenarios evaluated. Therefore, in order to explore the impact of the variability in the exposure terms to overall intake and resulting hazards, these two subsets of fisher scenarios are discussed separately below.

Hypothetical fishers assumed to be exposed to sediments at Beach Area E, in combination with other exposures, were estimated to have the greatest noncancer and cancer hazards. The deterministic evaluation of these scenarios established that assumed exposure to dioxins and furans in sediment at this beach area contributed the vast majority (i.e., ≥98 percent in the deterministic evaluation) of the resulting hazards. Hypothetical fishers exposed to these sediments, and consuming catfish from FCA 2/3 (i.e., Scenario 3A) exhibited the highest overall hazard of any hypothetical fisher scenario evaluated. In the probabilistic analysis, none of the 50th percentile endpoint-specific noncancer or cancer HIs for this hypothetical fisher population exceeded 1, however the 90th and 95th percentile HIs did exceed 1. The 50th, 90th, and 95th percentile noncancer HIs for reproductive/developmental effects were 1, 8, and 10 respectively. For this same scenario, the 50th, 90th, and 95th percentile HIs estimated for the immunotoxic endpoint were 0.4, 2, and 4 respectively (Table 5-22). These estimated reproductive/developmental hazards were attributable to potential exposure to TEQ<sub>DF</sub> in sediment and catfish fillet, and methylmercury in catfish fillet. Estimated hazards for immunotoxicity were attributable to potential exposures to PCB in tissue. The 50th, 90th, and 95th percentile TEQ<sub>DF</sub> cancer HIs were 0.4, 2, and 4 (Table 5-23). For hypothetical fishers exposed to sediments at Beach Area E and assumed to consume clams or crabs, noncancer hazards for reproductive/developmental endpoints and dioxin cancer hazards were equal to those for the fisher described above. A sensitivity analysis revealed that the most influential factor in the overall variability in the noncancer and cancer hazards was the concentration of TEQ<sub>DF</sub> in sediments. This factor accounted for over 50 percent of the variability in the predicted outcomes.

For the remaining subset of hypothetical fisher scenarios evaluated (i.e., those fishing scenarios that included assumed direct contact with sediments at Beach Area A, B/C, or D in combination with consumption of catfish or clam [Table 5-19]), consumption of tissue accounted for the majority of potential exposure to COPCHs. For this subset of fishing scenarios, the 90<sup>th</sup> and 95<sup>th</sup> percentile dioxin cancer hazards were all below 1 (Table 5-23). Upper percentiles of endpoint-specific noncancer hazards for hypothetical fishers assumed to be exposed to sediments and consuming clams (i.e., Scenario 2B) were also below 1 (Table 5-22). For fishers hypothetically exposed to sediments outside of Beach Area E and consuming catfish the 50<sup>th</sup>, 90<sup>th</sup>, and 95<sup>th</sup> percentile estimates of HIs for developmental/reproductive effects were 0.5–0.6, 2, and 3–4, respectively (Table 5-22). For these same fishers, the 50<sup>th</sup>, 90<sup>th</sup>, and 95<sup>th</sup> percentile estimates of the HIs for the immunotoxic endpoint ranged were 0.4, 2, and 4, respectively (Table 5-22). The greatest sources of variability in the noncancer and cancer hazards for these scenarios were the assumed ingestion rate for fish and the fraction of fish ingested that were from within USEPA's Preliminary Site Perimeter. Collectively, these factors accounted for over 80 percent of the predicted noncancer outcomes.

As discussed above in the deterministic evaluation of background risks and as demonstrated with the PRA using background concentrations (Table 5-22, Figure 5-8), a portion of these estimated hazards were also present under exposure to background conditions. Figure 5-8 shows the cumulative probability distribution for noncancer HI for reproductive/developmental effects for hypothetical fishers assumed to be exposed to sediments at Beach Area D and catfish fillet from FCA 1. These hazards were associated with potential exposures to TEQ<sub>DF</sub> in sediment and TEQ<sub>DF</sub> and methylmercury in catfish. The resulting cumulative probability distribution for hypothetical fishers assumed to be exposed to concentrations of TEQ<sub>DF</sub> in background sediments, and TEQ<sub>DF</sub> and methylmercury in catfish fillet are also shown. For any given exposure percentile shown on Figure 5-8, the horizontal distance between the two curves displays the incremental additional hazard assumed to be contributed by the area under study, i.e. the difference in hazards for the area under study relative to hazards for background conditions.

#### 5.2.3.3.2 Hypothetical Young Child Recreational Visitor

For the hypothetical young child recreational visitor, only a single scenario was evaluated using the PRA (Table 5-19). This scenario assumed a young child had direct contact to both sediments at Beach Area E and soils throughout the area north of I-10. TEQ<sub>DF</sub> was the only COPCH identified as a potential risk driver for soils and sediments, and therefore, only hazards associated with TEQ<sub>DF</sub> were evaluated for the PRA.

For the hypothetical young child recreational visitor, estimated 50th, 90th, and 95th percentile noncancer TEQ<sub>DF</sub> HIs were 0.2, 2, and 4 respectively (Table 5-22). The estimated 50th, 90th, and 95th percentile for cancer TEQ<sub>DF</sub> HIs were lower at 0.05, 0.7, and 1, respectively (Table 5-23). The resulting probabilistic noncancer and cancer hazards associated with potential exposure to TEQ<sub>DF</sub> in soils and sediments were more than an order of magnitude lower than the estimated deterministic TEQ<sub>DF</sub> noncancer HI of 60 and cancer HI of 20.

#### 5.2.3.3.3 Discussion of PRA Results

The results of the PRA provide insight into the variability of exposures and risks that may occur within the potentially exposed population. By comparing the deterministic estimates of hazards with the probability estimates, it is apparent that variability in various factors that influence exposure has a large impact on estimated hazards to the population (Table 5-22 and 5-23). Because the deterministic RME estimates for the hypothetical young child did not account for these sources of variability, they likely overestimated any actual risks.

Even in the PRA, some aspects of variability were not accounted for. The probabilistic risk calculations were structured to use a single exposure point concentration for each iteration. This is equivalent to assuming that an individual eats fish containing the same COPCH concentration, or contacts soils or sediments with the same COPCH concentration, on every exposure event throughout his or her entire exposure period. In reality, it is more likely that hypothetically exposed individuals move around the area under study and are exposed to variable concentrations of COPCHs over the durations of their assumed exposures. As a result, the exposure point concentrations to which they will actually be exposed will approach an average value over time. Such averaging would tend to pull both upper and

lower tails of the risk distributions toward the central risk estimate, and would reduce estimates of upper percentile values. The impact of such an assumption on the model's output is largest when the actual variability in concentrations of a COPCH that a person could potentially contact is large. As exhibited by the sensitivity analysis for hypothetical fishers exposed to sediments at Beach Area E, this was the case for TEQ<sub>DF</sub> in sediments at Beach Area E.

#### **5.2.4     *Uncertainty Analysis***

According to USEPA (1989) guidance, risk characterization should also present information important to interpreting risks in order to place the risk estimates in proper perspective. There are numerous areas of uncertainty in any risk assessment, and assumptions made in the absence of information are often intentionally conservative and, therefore, tend to drive results toward overestimates of risk. Uncertainties exist in each step, including the data collection and analysis, the estimation of potential site exposures, and toxicity assessment. This section discusses the significant sources of uncertainty in this BHHRA.

##### **5.2.4.1     *Uncertainties in Data Collection, Analysis, and Treatment***

There are a number of uncertainties related to data collection, analysis, and treatment. The more significant sources of uncertainty, as well as some that the EAM identified for discussion in this BHHRA, are discussed below.

In several samples from the 1966 perimeter of the northern impoundments, matrix interferences resulted in elevated detection limits for Aroclors. The use of these elevated detection limits for the sum of Aroclors would substantially overestimate sediment EPCs for total PCBs. Instead, one-half the detection limit for Aroclor 1254 in this subset of samples was substituted for deriving the EPCs for total PCBs. No Aroclors were detected in surface sediment within the 1966 perimeter and only a single detected concentration of Aroclor 1254 was measured at depth (2–4 feet) within this area (i.e., Station SJGB014, 1,400 µg/kg [qualifier J]). Moreover, in the *Screening Site Assessment Report* (TCEQ and USEPA 2006), which reported Aroclor results for several samples from within the wastes in the western cell of the northern impoundments, Aroclors were never detected. Aroclors were never detected in sediment samples, and detection limits for Aroclors in a number of sediment samples from

within the northern impoundments were normal (9.5 µg/kg). In summary, there is uncertainty about the actual Aroclor concentrations in the materials collected from within the 1966 perimeter, but the estimated concentration of Aroclor 1254 at station SJGB014, and results of TCEQ and USEPA (2006) sampling, confirm that the approach taken to estimating total PCBs in sediment was conservative.

There are also uncertainties introduced with the data rules applied in the calculation of EPCs for the area under study. Following the data rules established for this assessment, TEQ<sub>DF</sub> was calculated in two ways. First, individual congeners that were not detected in a sample were estimated to be present at one-half of the detection limit of that individual congener. Second, non-detected congeners were treated as zero. The impact of the decision on the resulting TEQ<sub>DF</sub> is dependent on both the number of congeners that were not detected and the detection limits for the congeners that were not detected. By comparing the resulting EPCs calculated using these two approaches, the impact of the uncertainty was determined. The ratio of EPCs for TEQ<sub>DF</sub> applying one-half the detection limit to TEQ<sub>DF</sub> applying zero was generally small for the media and areas that resulted in the largest hazard. For sediments in Beach Area E and catfish from FCA 1 and FCA 2/3, the ratios were less than 1.05. Therefore, any uncertainty introduced by the treatment of non-detects did not substantially influence the risk results.

Consistent with comments received from USEPA on the Tissue SAP (Integral 2010b, Appendix C), total PCBs in tissue were evaluated as the sum of 43 specific PCB congeners (Table 3-3). This approach is consistent with that used by the Seafood and Aquatic Life Group (SALG) of the Texas Department of State Health Services (TDSHS) and is based on recommendations regarding the likelihood of occurrence in fish and the likelihood of significant toxicity (TDSHS 2008, MacFarland et al. 1989). Under the analytical methods used for measuring PCB concentrations in tissue, an additional 20 PCB congeners co-eluted with the 43 congeners of interest. These additional congeners, which included PCB-20, -30, -47, -61, -65, -69, -76, -83, -86, -90, -97, -109, -113, -115, -125, -129, -135, -163, -166, and -193, were also included in the sum for total PCBs. The use of this final metric for predicting hazards and risks from PCBs introduced some uncertainty into the risk assessment and may have resulted in overstated risks as the addition of these congeners, which are considered less toxic, means that the combined concentrations of the 43 specific congeners that are

considered more toxic may have been overestimated. At the same time, there are other PCB congeners that were detected in sample results but were not included in this approach. The toxicities of these congeners are unknown but if any of these contribute additional toxicity to the mixture, then total risks to PCBs could be underestimated.

#### **5.2.4.2      *Uncertainties in Exposure Estimates***

There are a number of uncertainties in the estimates of exposure at the area under study. These include both uncertainties regarding uses associated with the area under study, as well as the specific assumptions used to quantify risk. The more significant sources of uncertainty related to the exposure assessment are discussed below.

#### **5.2.4.3      *Minor Exposure Pathways***

There are a number of minor exposure pathways for the area under study that were not evaluated quantitatively in this BHHRA. These included the potential inhalation of entrained dust derived from soil or sediment, inhalation of volatile compounds present in soil or sediment, and direct contact with surface water. While it is possible that these pathways could contribute additionally to total risk, any contribution would be very small, based on the COPCHs evaluated, and would not have affected estimated risks and hazards if they had been quantified.

Generally speaking, risks due to the inhalation of entrained dust originating from soils in the area under study are orders of magnitude lower than risks due to direct contact pathways (i.e., incidental ingestion and dermal contact) for soil. Therefore, any contribution from them is very minimal. In addition, because sediments have a high moisture content, it is not expected that they would provide a source of dust. While inhalation of volatiles in soil or sediment, if present, can contribute to total risk, none of the COPCHs identified is considered to be volatile.

It is possible that hypothetical receptors could be exposed to COPCHs in surface water, via incidental ingestion of surface water or via dermal contact during their activities, if those COPCHs are present in surface water. However, none of the COPCHs identified are likely to be dissolved in water at significant concentrations. The only other potential exposure routes

to COPCHs in surface water would be dermal contact with or incidental ingestion of COPCs that are adhered to sediment particles suspended in the water column. Because direct contact with sediments (i.e., incidental ingestion and dermal contact) has already been evaluated for all hypothetical exposure scenarios, it is expected that these analyses are inclusive of any potential exposures that could occur through contact with surface water.

#### **5.2.4.3.1 Hypothetical Trespassers**

Potential exposures and associated risks were not quantified for a hypothetical trespasser exposed to media in the area north of I-10 and the aquatic environment. Although a hypothetical trespasser could be exposed via the same pathways as the hypothetical recreational visitor (i.e., direct contact pathways) and the hypothetical recreational fisher (i.e., ingestion of fish and shellfish), the hypothetical trespasser exposure would likely be intermittent and of a shorter term duration than the exposures assumed for either of those scenarios (e.g., chronic durations of up to 33 years). Therefore, for the area north of I-10, the estimated risks and hazards presented for the hypothetical fishers and recreational visitors overstate potential risks for the hypothetical trespassers.

Ingestion of catfish from the area under study and assumed direct contact with sediments at Beach Area E contributed to estimated potential noncancer and dioxin cancer hazards greater than 1 for hypothetical recreational fishers and recreational visitors. The highest potential noncancer and dioxin hazards associated with the ingestion of tissue for the hypothetical recreational fisher were 2 and 0.3 respectively. It is likely that any hypothetical trespasser would consume, on average, less than one-half the amount of tissue from the area under study as that assumed under the hypothetical recreational fisher scenario. Therefore the estimated noncancer and dioxin cancer hazards from ingestion of tissue would be less than 1 for the trespasser. Although the potential hazards assumed to occur with direct contact exposures at Beach Area E would likely be less for a hypothetical trespasser compared to the receptors evaluated quantitatively in this BHHRA, using the same model as employed for the quantitative risk assessment of other receptors, estimated noncancer and dioxin cancer hazards might be greater than 1 for a hypothetical trespasser with direct contact to sediments in this area.

Under post-TCRA conditions, it is possible that a hypothetical trespasser might have access to Beach Areas B/C and D. Any exposure to these areas would likely be intermittent. More frequent and longer term exposures assume to occur to sediments in these areas did not contribute significantly to risks for the hypothetical recreational fisher or visitor receptor groups evaluated. Therefore, potential direct contact exposure in these areas is also unlikely to contribute significantly to exposures and associated risks for a hypothetical trespasser.

#### **5.2.4.3.2 The Presence of Subsistence Fishers**

The hypothetical subsistence fisher scenario was evaluated to address the concern raised by USEPA that there might be individuals who fish exclusively from within USEPA's Preliminary Site Perimeter over an extended period of time to provide food for themselves and other family members and, therefore, consume more fish from the area than other recreational anglers. While the Public Health Assessment for the Site (TDSHS 2012) describes the northern impoundments as having once been a popular fishing location, the ancillary evidence neither supports the presence of a subsistence fishing population, nor does it support the conclusion or assumption that the area has been heavily and consistently used by the same individuals for fishing at a subsistence level across decades.

It is rare that true subsistence fishing populations are found. However, there are several ways in which a subsistence population might be defined. The use of the word "subsistence" can be taken to mean that the individual is living, in whole or in part, at the minimum level of food/and or shelter needed to support life. In the context of fishing, however, it typically refers more generally to an individual who relies on self-caught fish as a primary source of dietary protein. Among various subpopulations, cultural, ethnic, or socioeconomic factors may influence fish consumption behavior at subsistence levels. For these reasons, the potential subpopulations that might have higher ingestion rates include: 1) low income individuals who need to supplement their diets with self-caught fish, 2) ethnic groups (such as some Native American tribes) for which consumption of substantial quantities of fish has historically been part of their cultural tradition, or 3) subpopulations of sport anglers who consume higher levels of fish than the general recreational angler population.

Substantiation of the existence of low income populations who rely on self-caught fish as their primary source of dietary protein has not occurred in most survey efforts conducted. In fact, based on available information, it appears that low income is not a predisposing factor leading to high levels of self-caught fish consumption (Javitz 1980; West et al. 1989, 1991; Connelly et al. 1990; Anderson and Rice 1993; Ebert et al. 1993; Degner et al. 1994; SMBRP 1994). Although some surveys have indicated that arithmetic mean consumption rates may be somewhat higher for low income groups than they are for the general angler population, the highest rates of consumption are generally not linked to income level. In fact, in many surveys, the highest rates have been reported for anglers who are in the highest income brackets and/or have advanced levels of education (McLaren/Hart ChemRisk 1996; West et al. 1989; Connelly et al. 1992, 1996). Therefore, the presence of apparently low income people at a fishery does not necessarily indicate that subsistence fishing is occurring.

There are Native American tribes whose members consume greater amounts of fish than the general angler population (Wolfe and Walker 1987; Dewailly et al. 1989; NYSDOH 1993; Richardson and Currie 1993; Coad 1994; CRITFC 1994; Degner et al. 1994; Kinloch et al. 1992). Beyond these fairly well-defined and well-characterized populations, the definition of an ethnic subsistence fisher is less clear. While there has been conjecture that other ethnic groups may consume at higher levels than the general angler population, the vast majority of available data indicate that there are no substantial differences in consumption based on race or ethnicity (Landolt et al. 1985; Connelly et al. 1992; Anderson and Rice 1993; McLaren/Hart ChemRisk 1992; SMBRP 1994). While West et al. (1989) reported that average consumption rates among certain ethnic/racial groups were higher than the average for Caucasian anglers, the maximum consumption rate reported for this study was for a Caucasian angler. The same was true for a survey conducted in Maine (Ebert et al. 1993). In addition, a survey conducted of the large Hmong population living in Green Bay, Wisconsin indicated that, although the average consumption rate for this population was slightly higher than the average for the general Wisconsin angler population, and these individuals preferred to eat different species of fish, the maximum fish consumption frequency (which was reported by roughly 8 percent of the surveyed anglers) was two to three times per week (Hutchison and Kraft 1994). Similar to the situation with income levels, the presence of individuals of certain races or ethnic groups at a fishery does not necessarily indicate that subsistence behavior is occurring.

Although there are individuals within the general angler population who consume fish at high rates, their numbers are small. For example, in a state-wide survey of Maine's freshwater anglers, a maximum consumption rate of 182 g/day was calculated but the second highest rate calculated was 80 g/day and the 95th percentile for the 1,053 anglers who reported they consumed fish was 26 g/day, demonstrating that the vast majority consumed at much lower rates. Similarly, West et al. (1989) reported a maximum consumption rate of 224 g/day but the 95th percentile consumption rate from that study was 39 g/day, indicating that very few individuals consumed at very high rates.

It is not reasonable to assume that upper-bound anglers who may have fished at the northern impoundments have fished there exclusively. Information collected during the intercept survey conducted by de la Garza & Associates, as part of the Community Engagement Initiative and with participation by USEPA (de la Garza 2011) indicated that individuals tended to move between multiple locations including Riverside Terrace Park, the bridge near I-10, and the islands of Burnett Bay. While the bridge near I-10 is within USEPA's Preliminary Site Perimeter, Riverside Terrace Park (also known as River Terrace Park) and the islands of Burnett Bay are located outside of USEPA's Preliminary Site Perimeter. These data indicated that anglers who fish within USEPA's Preliminary Site Perimeter probably only consume a fraction of their fish from any single location.

Given the general lack of evidence of subsistence behaviors and the specific lack of any evidence for subsistence fishing within USEPA's Preliminary Site Perimeter, the subsistence fisher, as evaluated in this BHHRA, is hypothetical and unlikely to be or have been present in the area under study. This is made even more unlikely under current (post-TCRA) conditions because any access to the area within USEPA's Preliminary Site Perimeter is highly restricted by fencing.

#### **5.2.4.3.3 Estimated Exposure from Fish Consumption**

A number of the assumptions used in estimating exposure to COPCHs in finfish and shellfish are uncertain. These include the selection of one tissue type to represent all types of fish that

an individual may consume, the selected finfish and shellfish ingestion rates assumed, and the chemical reduction due to preparation and cooking.

In this BHHRA, exposures associated with assumed finfish consumption were estimated using catfish fillet data. It is unlikely that any individuals who fish and who consume fish from the area under study would consume only catfish at the ingestion rates assumed. It is more likely that they would consume a mixed diet that includes a variety of fillet types. In the Lavaca Bay study, only one individual of the 1,751 anglers who reported fish consumption in that survey reported that he and his family consumed hardhead catfish during the month-long study period. Even when all types of catfish that were reported (hardhead, gaftopsail, blue, and channel catfish) were combined, only 148 (less than 1 percent) of 15,778 meals reported were catfish of any species.

Hardhead catfish are benthic fish that tend to accumulate higher concentrations of persistent bioaccumulative chemicals, including dioxins and PCBs, than many of the species that are generally targeted for consumption. A review of available Category 2 data collected in 2005 and later from the regional area shows that TEQ<sub>DF</sub> concentrations in catfish are higher than concentrations in the fillets of other species (Figure 5-9) (TDSHS 2010, University of Houston and Parsons 2006). These data suggest that if a mixed diet of various fish types was modeled for this BHHRA, the resulting hazards (both cancer and noncancer) from TEQ<sub>DF</sub> would be lower than were estimated here. The precise difference in that risk is unknown and would vary, depending on the species mix considered.

Although the fish and shellfish ingestion rates from Lavaca Bay were determined to be the best available for this BHHRA, there is some uncertainty with their application for this BHHRA. As part of this BHHRA, in addition to the reported results, the raw data for the Lavaca Bay study were reviewed and provided additional insight into some of the uncertainty associated with these rates. For the young child, the data included 326 records for children who consumed finfish during the study period. However, during that same period, only 29 of these child consumers were reported consume shellfish despite the fact that they were fish consumers. Consequently, the population of fish consumers was quite large, but the subset of individuals who consumed shellfish was quite small. Similar differences are observed if other types of fish are segregated.

The report on the Lavaca Bay study handled this by including zero values for all of the fish consumers who did not consume shellfish during the study period in deriving the reported statistics for consumption rates for shellfish. The inclusion of these zero values resulted in central tendency and upper-bound consumption rates that were lower than they would have been if only those 29 children who consumed shellfish were considered in estimated consumption rates. An alternative approach would have been to develop a distribution that was based only on the consumption rates reported for individuals who actually consumed shellfish (i.e., 29 children). Using this approach, the median value was 4 g/day and the 95th percentile was 13 g/day. Had these values been applied as the CTE and RME ingestion rates for the young child, the resulting risks and hazards associated with the shellfish consumption pathway would have been approximately 7-fold higher than those presented for this BHHRA.

There is also uncertainty regarding the amount of fish that individuals eat that are from within USEPA's Preliminary Site Perimeter. Information on the fractional intake of fish and shellfish from various areas as reported in the Lavaca Bay study were used to inform the value assumed for this parameter in this BHHRA. Alcoa (1998) reported that the mean and 95UCL fractional intakes of finfish in the 1,500 acre closure area studied within Lavaca Bay were less than 10 percent, and the fraction of shellfish consumed from the area was even lower, at less than 1 percent. For this BHHRA, RME and CTE fractional intakes for fish and shellfish of 0.25 and 0.1 were assumed for the hypothetical recreational fisher scenario, and a fractional intake of 1.0 was assumed for the hypothetical subsistence fisher scenario. The assumed values are likely conservative; however, the lack of information specific to the area under study does not allow the term to be more accurately defined for this BHHRA.

Another uncertainty in estimating exposure from the ingestion of tissue is related to the loss factor assumed for preparation and cooking. It is well recognized that tissue preparation and cooking methods used may reduce chemical concentrations in fish tissues, particularly for lipophilic compounds such as dioxins, furans, and PCBs (USEPA 2000b, 2002b; Wilson et al. 1998). There is some uncertainty, however, regarding the precise amount of chemical-specific reduction that occurs. For the deterministic exposure evaluation, a cooking loss term of 0 percent (no loss) was conservatively assumed for PCBs and dioxins.

As established in the EAM (Appendix A), the impact of assuming a cooking loss factor of 0.25 (25 percent) was explored in the uncertainty evaluation for this BHHRA. In addition, the PRA applied distributions for this chemical reduction factor for dioxins and PCBs. These distributions are described in detail in Appendix G.

The loss parameters were applied to catfish fillets only, and not to clams or crabs. TEQ<sub>DF</sub> and PCBs contributed a substantial amount of the potential noncancer hazards from catfish ingestion. There is a direct linear relationship between the cooking loss factor for a chemical and total intake of (and hazard or risk attributable to) that chemical from tissue. Therefore, when a cooking loss factor of 0.25 was applied, the noncancer hazards and risks attributable to TEQ<sub>DF</sub> and PCBs were reduced by 25 percent.

For the hypothetical recreational fisher, when cooking loss was assumed to be zero, the assumed consumption of catfish tissue from FCA 2/3 resulted in a noncancer HI of 2.3 for all COPCHs and an HI of 2.0 for TEQ<sub>DF</sub> and total PCBs combined. Applying a loss factor of 0.25 resulted in reduced HIs of 1.8 and 1.5, respectively, or a 21 percent reduction in total hazard. The contribution of TEQ<sub>DF</sub> and PCBs to overall hazard from consumption of catfish was similar for FCA 1 (i.e., 85 percent compared to 83 percent). Applying the cooking loss factor of 0.25 resulted in a 21 percent reduction in total hazard attributable to consumption of catfish in FCA 1. The relative impact of this factor (i.e., 21 percent) on the resulting noncancer hazards for the hypothetical subsistence fisher was the same as for the hypothetical recreational fisher.

No loss factors were evaluated for clams or crabs because no data on chemical reduction due to preparation and cooking specific to shellfish could be located. Clam tissue analyzed from locations within USEPA's Preliminary Site Perimeter had a substantially lower percent lipid than most finfish, and techniques used for preparing and cooking shellfish differ from those used for finfish. Therefore, no alternative cooking loss factor was explored for shellfish. However, if there is also a loss of COPCH concentrations when shellfish are cooked, then the estimated risks and hazards may be over-stated.

A recent meta-analysis published by AECOM (2012) reviewed the available data on cooking loss for lipophilic compounds. Studies completed in a variety of tissue types and applying a range of preparation and cooking methods were reviewed, and those with sufficient data for quantitative analysis were used to determine the range and midpoint of cooking loss for dioxins and PCBs. The analysis focused on studies that used a relevant and appropriate experimental method and presented changes in raw and cooked fish tissue COPC levels on a mass basis because a comparison of concentrations in raw and cooked fish alone neglects the change in tissue mass that occurs with cooking, which is often significant. The median losses were generally in the range of 20 to 50 percent for typical cooking methods and consistent differences in mass loss between cooking methods were not apparent. Across all tissue types and cooking methods, the median losses were 32 percent for PCBs and 50 percent for dioxins and furans. The results of this recent meta-analysis suggest that the hazards presented in the deterministic risk assessment, which relied on a loss of 0, are conservative, and that the impact of actual losses is even greater than those discussed above in this uncertainty evaluation which assumed a 25 percent loss factor.

#### **5.2.4.3.4 Estimated Exposure from Direct Contact Pathways**

There are also some uncertainties associated with certain assumptions used for estimating exposure via direct contact. These include the use of a maximum concentration of dioxins and furans for the EPC at Beach Area E, adopted sediment adherence factors and assumptions about exposure patterns and frequencies.

Employing the rules established in the EAM for selecting EPCs, the maximum concentration of TEQ<sub>DF</sub> in sediments at Beach Area E was selected as the EPC for the RME estimate (Appendix E). The selection of this maximum concentration introduced a large amount of uncertainty into the risk estimates for direct contact with sediments at this Beach Area. At Beach area E, TEQ<sub>DF</sub> concentrations ranged from 8.5 to 13,000 ng/kg and the geometric mean concentration was 910 ng/kg. The RME EPC of 13,000 essentially resulted in the assumption that individuals are exposed to only sediment with this high concentration of TEQ<sub>DF</sub> for the entirety of time spent in this area. It is much more likely, that over an extended duration, under the baseline condition considered in this BHHRA (i.e., immediately prior to the TCRA), individuals would have been exposed to an average concentration of dioxins and

furans present in sediments at this Beach Area. The geometric mean concentration of 910 ng/kg was adopted as the EPC for the CTE estimates. The CTE cancer and noncancer TEQ<sub>DF</sub> HIs for direct contact with sediments at this Beach Area were 0.08 and 0.3 respectively, and were two orders of magnitude lower than the corresponding RME estimates. Although the differences in the CTE and RME estimates reflected other differences in the scenarios in addition to the EPC, the 14-fold difference between the RME and CTE EPCs assumed for this scenario was one of the factors that heavily influenced the differences in these estimates. Given the wide range of variability in TEQ<sub>DF</sub> concentrations in sediments present at Beach Area E, as described above this assumption had large implications for the risk results. Specifically, TEQ<sub>DF</sub> noncancer and cancer hazards are 14-fold lower when the CTE EPC is assumed in place of the maximum concentration.

Few studies have evaluated adherence of sediments to exposed skin; however, it has been established that adherence for wet soil or sediment are generally higher than for dry soil (USEPA 2011a; Bergstrom et al. 2011). In addition to the moisture content of the exposure medium, the particle size makeup of the medium may impact adherence. The sediment values presented in USEPA (2011a) and used for the deterministic evaluation were based on body part-specific adherence factors from Shoaf et al. (2005). This study measured sediment adherence in children playing in tidal flats composed primarily of sandy sediments, and established adherence factors ranging from 0.042 mg/cm<sup>2</sup> for the face to 21 mg/cm<sup>2</sup> for the feet. These body-specific adherence factors were used to determine a weighted adherence factor of 3.6 mg/cm<sup>2</sup> for the hypothetical young child fisher and recreational visitor scenarios.

The sediments at Beach Areas A, B/C, D, and E consist of a range of particles with the bulk being finer grained sediments including silt, very fine sand, and fine sand (Figure 5-10). Overall, these sediments appear to be finer than those studied by Shoaf et al. (2005) and, therefore, there is a degree of uncertainty introduced by the use of these factors in this BHHRA. Given the higher concentrations of COPCHS in sediments at Beach Area E, the impact of this uncertainty is greatest for the hazards and risks estimated for direct contact with Beach Area E. For example, if an adherence factor for soil had been applied in the place of that for sediments, hazards resulting from direct skin contact with sediment would have been reduced by more than an order of magnitude.

The theoretical relationship between particle size and the mass required to provide monolayer coverage is important to understanding the potential for chemical absorption. Monolayer loading is defined as the complete coverage of skin with one layer of particles. Experimental results show that the monolayer is a critical level: soil layers above the monolayer contribute very little to dermal absorption (USEPA 2011a). The soil load required to reach a monolayer depends on the particle size of the soil. Using the relationship established by Duff and Kissel (1996), the load representing monolayer ranges from 4.3 mg/cm<sup>2</sup> for clay particles to 208 mg/cm<sup>2</sup> for coarse-grained sand. This theoretical demonstration is a simplification for any real application because real layers of soil or sediment consist of heterogeneously sized, irregular particles, however the large resulting range in monolayer loads demonstrates the large amount of potential variation in true adherence.

#### **5.2.4.4      *Uncertainties in Toxicity Evaluation***

Dioxins and furans were defined as risk-driving chemicals in sediments, soils, and tissue. PCBs were defined as risk-driving chemicals in tissue. Therefore, the focus on the uncertainties introduced by the toxicological criteria applied for this BHHRA are focused around those COPCHs. While mercury was also defined as a risk driving chemical in catfish, the mercury concentrations in catfish were not statistically different from background mercury concentrations in catfish. Therefore, uncertainty in the toxicological evaluation of mercury is not further discussed.

##### **5.2.4.4.1      Dioxin and Furan Toxicity**

The toxicity criterion that was used to evaluate potential cancer risks due to dioxins and furans (i.e., as TEQ<sub>DF</sub>) was the TDI of 2.3 pg/kg-day derived from JECFA (2002). This TDI was developed based on the assumption that the cancer dose response for TCDD and other DLCs is not linear and that there is a threshold for the carcinogenic effects of these compounds. There is substantial support for using a threshold approach to evaluate DLCs (WHO 1991, 1992, 1998; JECFA 2002; Simon et al. 2009; NAS 2006; ACC 2010; TCEQ 2010a,b, 2011; Haney 2010).

While the threshold-based approach for carcinogenic effects has been discussed in the draft dioxin reassessment, it has not yet been adopted by USEPA as the basis for its cancer-based toxicological criterion. USEPA's historical approach has been to assume that the carcinogenic effects of dioxins and furans have no threshold dose, and to use a CSF to evaluate potential cancer risks, assuming that the dose response is linear. As discussed in Section 4.3.1, USEPA has been conducting its dioxin reassessment for nearly 20 years. While the scientific consensus during that period has been growing to conclude that DLCs act via a non-linear dose response, USEPA's most recent report on its reassessment indicates that it has not yet changed its assumption that TCDD acts as a non-threshold carcinogen.

Historically, USEPA has used an upper-bound CSF of  $150,000 \text{ (mg/kg-day)}^{-1}$  for TCDD (USEPA 1997b), based on the increased incidence of hepatocellular and respiratory tumors reported in the Kociba et al. (1978) study and extrapolation using a linearized multistage model.<sup>26</sup> It should be noted, however, that in addition to the value that was developed by USEPA using these data, a number of other agencies and independent scientists have used the same data to derive a variety of linear-based CSFs for TCDD. These CSF estimates have ranged from 9,000 to  $156,000 \text{ (mg/kg-day)}^{-1}$  (USEPA 1985, 2000a; FDA 1993, 1994; Keenan et al. 1991). The differences among them are the result of changes in tumor classification protocols that have occurred since the earlier studies were conducted, selection of approaches for scaling from animals to humans, early mortality corrections, the selected tumor types upon which the dose response models are based, and the choice of the specific linear extrapolation model used to evaluate them. Therefore, the decisions that must be made in extrapolating the results from animal studies to derive a CSF can greatly impact the resulting CSF estimates, adding greatly to their uncertainties, even when the same starting data are used.

Further uncertainty in the CSF approach is introduced considering that other scientists have developed CSFs based on data that are more recent than the Kociba et al. (1978) study. California EPA (CalEPA 1986) completed multiple analyses and based its CSF of  $130,000 \text{ (mg/kg-day)}^{-1}$  on the incidence of liver tumors in male mice observed in the National Toxicology Program (NTP) mouse bioassay (NTP 1982). Subsequently, the California

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<sup>26</sup> USEPA (1985) published a slightly higher CSF of  $156,000 \text{ (mg/kg-day)}^{-1}$  in its 1985 Health Assessment document based on these same data.

OEHHA (2007) used a CSF of 26,000 (mg/kg-day)<sup>-1</sup>, which was based on the results of a more recent NTP (2006) study, in deriving its 2007 drinking water criteria. Simon et al. (2009) developed a CSF of 100,000 (mg/kg-day)<sup>-1</sup> using the same NTP (2006) dataset but used a body burden approach, rather than an administered dose, to derive a linearized CSF. Finally, USEPA (2011b) has indicated that it may increase its CSF to 1,000,000 (mg/kg-day)<sup>-1</sup>, based on its application of a linear dose response approach model to epidemiological data.

Alongside the wide range in estimated CSF values that assume a linear dose-response relationship between TCDD and cancer, there is growing worldwide consensus that TCDD's cancer effects have a threshold. A number of agencies and scientists have derived toxicological criteria that are based on a threshold dose instead of a linear dose-response model. These toxicological criteria range from 1 to 100 pg/kg-day. Simon et al. (2009) derived an RfD of 100 mg/kg-day for the cancer endpoint using the 2006 NTP data. The World Health Organization (WHO) (1991, 1992) developed a TDI of 10 pg/kg-day, which it believed to be protective of cancer effects, based on its review of the available toxicological literature. Subsequently, in concert with the International Programme on Chemical Safety, WHO developed a revised TDI range of 1 to 4 pg/kg-day, based on body burden data and using a steady state pharmacokinetic model, that it considered protective of both cancer and noncancer endpoints. In addition, JECFA's recommended toxicological criterion, which provides the basis for the TDI of 2.3 pg/kg-day that is used in this BHHRA, was based on body burdens reported for two animal studies. Table 5-24 provides a summary of key toxicological criteria that have been developed for TCDD.

The CSFs that have been derived using linear dose response modeling are not directly comparable to the dose-based toxicological criteria that have been developed, assuming that there is a threshold. It is possible, however, to compare the risk-specific doses<sup>27</sup> (RsDs) that can be derived using the CSFs with the threshold-based values.

Using a target cancer risk level of  $1 \times 10^{-4}$  to convert the various upper-bound CSFs ranging from 9,000 to 156,000 (mg/kg-day)<sup>-1</sup> to RsDs results in RsDs ranging from 0.64 to 11 pg/kg-

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<sup>27</sup> A risk-specific dose is the dose level that is associated with a specified level of cancer risk. It is calculated by dividing a target risk level by the chemical-specific CSF to determine the chemical-specific dose level that results in that cancer risk.

day. The target risk of  $1 \times 10^{-4}$  was selected as the basis for this comparison because it is the upper-bound of USEPA's target range for incremental cancer risk. Thus, it is analogous to the threshold dose for cancer, above which exposures may be determined to be unacceptable by USEPA. The values that have been derived assuming that DLCs act as threshold carcinogens range from 1 to 100 pg/kg-day. The JECFA value that was used in this BHHRA is higher than the lowest RsD by a factor of 3.6, but is lower than the upper end of that range by roughly a factor of 5. It is also at the low end of the range of threshold-based criteria; 2.3 times higher than the lowest value reported but more than 40 times lower than the upper end of that range. This indicates that while the TDI of 2.3 pg/kg-day is not the most conservative value that could have been used, it is well within the range and near the low end of the toxicological criteria that have been used by other agencies worldwide.

Although USEPA has not finalized its dioxin reassessment, its 2003 draft proposed a linear-based CSF of 1,000,000 (mg/kg-day)<sup>-1</sup>. When this CSF is used to develop an RsD based on a  $1 \times 10^{-4}$  target risk, it results in an RsD of 0.1 pg/kg-day. This is lower by nearly a factor of 7 than the lowest of the RsDs derived from Tier 3 studies (Table 5-24). The JECFA value is higher than that value by a factor of 23.

There are also substantial uncertainties associated with USEPA's recently published RfD of 0.7 pg/kg-day for TCDD, which was used to evaluate the noncancer effects of DLCs in this BHHRA. This value was based on studies conducted by Baccarelli et al. (2008) and Mocarelli et al. (2008). Both evaluated health effects in human populations that were exposed to dioxins and furans as the result of a trichlorophenol reactor accident that occurred in 1976 in Seveso, Italy (USEPA 2012b).

While this RfD has been adopted by USEPA, a number of questions arose during its peer review pertaining to the selection of appropriate NOAELs, pharmacokinetic consideration of increased elimination rates in children, correction for exposures to other dioxins and furans, and the full weight of evidence provided by other human and animal studies (SAB 2011; ACC 2010; Foster et al. 2010). USEPA did not resolve all of those issues prior to publishing the value in its IRIS database.

Differing values for noncancer effects have also been developed by other agencies worldwide. The ATSDR, WHO, the Joint United Nations Food and Agriculture Organization, the European Commission Scientific Committee on Foods, the Japanese Ministry of Health and Welfare, and the Health Council of the Netherlands and JECFA all derived dose-based quantitative health guidelines ranged from 1 to 4 pg/kg-day based on a number of different, noncancer, toxicological endpoints for TCDD and DLCs (DeRosa et al. 1999; Pohl et al. 2002; JECFA 2002). The lower end of that range is roughly 50 percent higher than USEPA's RfD and the upper end of that range is higher by nearly a factor of 6. Given the uncertainty in the actual noncancer toxicity of DLCs it is possible that the use of USEPA's RfD to evaluate noncancer hazards may have overestimated those hazards by as much as a factor of 6.

A substantial amount of the potential risks and hazards for the area under study were associated with potential exposures to DLCs in sediments and fish/shellfish tissues. Using the dioxin cancer hazard approach results in an estimated cancer hazard for the mixtures of these compounds measured in these media. Like a noncancer hazard index, if the cancer hazard exceeds 1, USEPA assumes that there is a potential for developing cancer within the exposed population based on exposure over the assumed exposure duration, while if the cancer hazard does not exceed 1, it is concluded that there is no risk of developing cancer. This differs from USEPA's traditional approach of estimating an incremental increase in potential cancer risk for carcinogenic compounds and comparing that risk to USEPA's target risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ .

The result of this is that reported cancer hazards for DLCs are not directly comparable, and, therefore, cannot be summed with the incremental cancer risks reported for the other carcinogenic compounds. While this can appear to complicate the interpretation of risk results, it is appropriate not to sum them. This is because the calculated cancer hazard, using the TDI, is similar to the endpoint-specific noncancer hazard. Therefore, if the cancer hazard exceeds 1, using USEPA's thresholds, USEPA assumes that there may be some risk of cancer under the assumed hypothetical scenario, whereas if it does not exceed 1, then it is assumed that the DLCs do not contribute to the potential cancer risk for that same scenario.

#### 5.2.4.4.2 PCB Toxicity

As discussed in the TESH (Appendix B) there is some uncertainty associated with the way in which PCBs were evaluated. USEPA's IRIS database, which presents CSFs and RfDs for PCB mixtures with variable degrees of chlorination, also states that (USEPA 2011a):

“when congener concentrations are available, the slope-factor approach can be supplemented by analysis of dioxin TEQs to evaluate dioxin-like toxicity. Cancer risks from dioxin-like PCB congeners (evaluated using dioxin TEQs) would be added to risks from the rest of the mixture (evaluated using slope factors applied to total PCBs reduced by the amount of dioxin-like congeners).”

While both of these approaches contribute uncertainties to the estimation of risks and hazards due to PCB, the uncertainties associated with the use of toxicological criteria that USEPA has developed for PCBs contributes less uncertainty.

USEPA's CSF for highly chlorinated PCB mixtures, which was used in this BHHRA, is based on upper-bound estimates of the toxicity of Aroclors 1248, 1254, and 1260. The RfD for Aroclor 1254 was used for evaluating noncancer hazards from potential exposure to PCBs. As long as the congener mixtures present in the exposure media are similar to these Aroclors, the risk and hazard estimates based on these criteria should be reliable and conservative. This is because the observed toxicity upon which the criteria have been based, represents the combined toxicity associated with all congeners that are present in that mixture. The observed toxicity, therefore, accounts for the contributions of all of the components of the mixture, their potential additivities, their agonistic and antagonistic interactions, and their competition for the same binding sites.

It is acknowledged, however, that congener mixtures in environmental media may differ from the Aroclor mixtures due to variations in congener uptake and bioaccumulation, and losses or alterations in the mixture due to weathering. This is one of the reasons that USEPA recommends using the TEQ approach to evaluate PCBs in addition to the PCB-specific toxicological criteria. There is concern that the composition of the PCB mixture that is present in media in the area under study may differ from the PCB mixture used to derive the toxicological criteria, due to aging and the variable physical/chemical properties of the

different congeners, so that the mixture no longer resembles the mixture upon which those criteria are based. Depending upon the congeners present, the toxicity of the aged congener mixture could be greater or less than the upper-bound values presented in IRIS.

To evaluate this possibility, an analysis of the PCB congener composition in the tissue used in this BHHRA was completed to determine whether it resembled the highly chlorinated mixtures upon which USEPA's recommended CSF and RfD are based. Specifically, the percent congener composition of Aroclors 1248, 1254, and 1260, as reported by Newman et al. (1998) were compared with the percent composition of congeners measured in the biota to determine whether the weathering and differential uptake may have resulted in a congener mixture in biota tissue that did not resemble that of the highly chlorinated Aroclor mixtures upon which USEPA's toxicological criteria are based.

As shown in Figures 5-11 through 5-13, that analysis indicated that the congeners present in catfish, clams, and crabs most closely resembled Aroclor 1254 or a mixture of Aroclor 1254 and 1260 and so also resembled those mixtures upon which the USEPA's toxicological criteria were based. Therefore, it can be concluded that the estimated risks and hazards for ingestion of PCBs in biota were appropriate and conservative estimates.

The alternative approach of evaluating TEQp, as presented by USEPA (2012b), contributed greater uncertainty to risk and hazard estimates for PCBs for a number of reasons, which are discussed below.

USEPA recommends evaluating the 12 dioxin-like PCB congeners using the toxicological criteria for TCDD, subtracting out their concentrations from the concentration in the total PCB mixture, and then evaluating the remaining mixture of 197 congeners using the toxicological criteria that were specifically developed for PCB mixtures. The health effects upon which USEPA has derived its toxicological criteria for PCB mixtures are believed to result from activation of the same AhR-mediated pathways that provide the basis for the "dioxin-like" toxicity of certain PCB congeners. Because it is likely that the dioxin-like congeners represent a substantial portion of the potential toxicity of the total PCB mixture, application of USEPA's toxicological criteria for total PCBs to the remainder of the PCB mixture (i.e., after subtracting the dioxin-like congeners from the total), is not scientifically

justifiable and will overstate risk for the remaining mixture. Because little is known about these non-dioxin-like congeners, the degree of overestimation cannot be determined.

In addition, the evaluation of PCBs using the TEQ approach requires that TEFs be used to convert measured concentrations of the 12 dioxin-like congeners to TEQ concentrations. There are substantial uncertainties associated with the TEFs that have been developed for these PCB congeners. These are due largely to several simplifying assumptions used in developing them, which are not well-supported in the scientific literature (Van den Berg et al. 2006; Roberts et al. 1990; Ema et al. 1994; Poland et al. 1994; Ramadoss and Perdew 2004; NAS 2006; Haws et al. 2006; Wiebel et al. 1996; Xu et al. 2000; Zeiger et al. 2001; Connor and Aylward 2006; Vamvakas et al. 1996; Silkworth et al. 2005; Carlson et al. 2009; Harper et al. 1995; Safe 1990; Starr et al. 1997; Toyoshiba et al. 2004; Walker et al. 2005; USEPA 2010d; SAB 2011). These include:

- The assumption that the dose-response curves for different congeners and endpoints are parallel.
- The assumption that the effects of multiple DLCs are additive.
- The assumption that humans are as sensitive as laboratory animals to the effects of DLCs.
- The assumption that noncancer endpoints and *in vitro* studies can be used to predict the carcinogenic potential of the individual DLCs.
- In addition, for a subset of PCB congeners, the TEF values were derived by comparing the toxicity of those congeners with that of 3,3',4,4',5-pentachlorobiphenyl (PCB-126) to develop relative effect potencies (REP) (Haws et al. 2006) rather than through direct comparison with TCDD. When developing REP estimates in this way, the principle of transitivity was invoked; that is, by quantifying both the toxicity of a DLC relative to PCB-126 and PCB-126 relative to TCDD, the toxicity of the DLC relative to TCDD can be estimated (USEPA 2010d). The TEF for PCB-126 was set at 0.1. Consequently, the PCB-126-based REPs were multiplied by 0.1 in the derivation of TEFs for other congeners in order to relate them to TCDD (Van den Berg et al. 2006). Given that the TEFs are meant to measure relative toxicity within an order of magnitude, and that two order-of-magnitude assumptions are being combined with this approach, this assumption could result in substantial over- or underestimation of

actual toxicity of those PCB congeners. These issues are discussed in more detail in Appendix B.

Despite these issues, a secondary analysis was conducted to provide perspective on the estimated risks that would have resulted if the TEQ approach had been used instead to evaluate this subset of congeners. The concentrations of the dioxin-like PCB congeners were converted to TEQ<sub>P</sub> concentrations, using the corresponding congener-specific TEFs, and the cancer risks from TEQ<sub>P</sub> were evaluated using the cancer-based TDI for TCDD. The resulting risks were then added to the risks for TEQ<sub>DF</sub> to derive a total risk for TEQ<sub>DFP</sub>. In this approach, the carcinogenic potential of the remaining, non-dioxin-like PCBs was not calculated and added to the total.

When cancer hazards due to TEQ were calculated for the assumed consumption of biota by hypothetical recreational fishers<sup>28</sup>, estimated hazards were lower than the threshold of 1 for all scenarios. For the scenarios with the highest cancer hazard for biota consumption (e.g., those scenarios that assumed the consumption of catfish from FCA 2/3), the cancer hazard associated with TEQ<sub>P</sub> was 0.13, the cancer hazard associated with TEQ<sub>DF</sub> was 0.33, and the total cancer hazard for TEQ<sub>DFP</sub> was 0.46 (Appendix H). The relative contributions of TEQ<sub>DF</sub> and TEQ<sub>P</sub> to total TEQ<sub>DFP</sub> cancer hazard were 72 percent and 28 percent, respectively (Table 5-25).

It is more challenging to compare total PCB cancer risk with the TEQ cancer hazard because the two values are not comparable. However, if one uses the CSF approach to compare the relative cancer risks calculated for TEQ<sub>DF</sub>, TEQ<sub>P</sub>, and TEQ<sub>DFP</sub> using USEPA's historical CSF for TCDD of 150,000 (mg/kg-day)<sup>-1</sup>, a similar result is observed. As shown in Table 5-25, the total cancer risk using this approach was  $3.6 \times 10^{-5}$ , with TEQ<sub>P</sub> contributing a risk of  $9.9 \times 10^{-6}$  and TEQ<sub>DF</sub> contributing a risk of  $2.6 \times 10^{-5}$ . Thus, in this comparison, TEQ<sub>DF</sub> also contributed 72 percent of the total risk. This is not surprising given that the relative concentrations of the individual congeners were the same, regardless of the toxicological criterion that was applied.

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<sup>28</sup> Comparisons of approaches could not be made for all pathways combined because PCB congeners were not analyzed in soils and sediments. As a result, the only media for which TEQ<sub>DFP</sub> could be calculated and discussed were biota.

Results were somewhat different when the cancer risk for total PCBs (as the sum of 43 congeners), estimated using the USEPA CSF for PCBs, were compared with the estimated cancer risk for TEQ<sub>DF</sub> using the same historical USEPA CSF. In this case, the cancer risk for total PCBs was  $7.9 \times 10^{-6}$ , the total cancer risk for TEQ<sub>DF</sub> was  $2.6 \times 10^{-5}$  and the total combined cancer risk was  $3.4 \times 10^{-5}$ . Therefore, TEQ<sub>DF</sub> contributed a slightly higher percentage of the total risk (77 percent).

This proportion changed considerably, however, depending on the CSF that was selected for evaluating the TEQ component. If the low end of the range of available CSFs (9,000 [mg/kg-day]<sup>-1</sup> based on FDA 1993) was used to evaluate TEQ<sub>DF</sub>, then the relative risk contribution by total TEQ<sub>DF</sub> was 16 percent. At the same time, if the upper end of the range of available CSFs (1,000,000 [mg/kg-day]<sup>-1</sup>) was used to evaluate TEQ<sub>DF</sub>, then TEQ<sub>DF</sub> provided 96 percent of the total risk (Table 5-25). Therefore, if a linear dose response was used to evaluate TEQ<sub>DF</sub>, the uncertainty about the correct CSF to be used to evaluate this mixture greatly complicates the interpretation of risk results.

IRIS does not discuss the approach to be used for evaluating noncancer effects of dioxin-like PCB congeners, so the same approach was used to evaluate the uncertainty associated with estimating noncancer effects of PCBs.

As shown in Table 5-25, when evaluating noncancer hazards, results varied depending upon the approach used. For recreational fish consumption under hypothetical Scenario 1A (i.e., direct contact with Beach Area A and consumption of catfish from FCA 2/3), the noncancer hazard for TEQ<sub>DF</sub> was 1.1 and the noncancer hazard for TEQ<sub>P</sub> was 0.42, for a total noncancer hazard for TEQ<sub>DF</sub> of 1.52. Using this approach, TEQ<sub>DF</sub> again contributed 72 percent of the total noncancer hazard. However, when the noncancer hazard for TEQ<sub>DF</sub> (1.1) was combined with the noncancer hazard for Total PCBs (0.88), calculated using the RfD for Aroclor 1254, the total noncancer hazard was estimated to be 1.98 and TEQ<sub>DF</sub> contributed only 56 percent of the hazard. This analysis indicated that the total PCB approach used to estimate noncancer hazards due to PCBs for this BHHRA resulted in higher (more conservative) estimates of the noncancer hazards associated with PCBs than would have been predicted if the TEQ<sub>DFP</sub> approach had been used instead.

It should be noted, however, that there is no indication that the endpoints that were selected as the basis for the TCDD RfD are also associated with PCB toxicity. Thus, combining the dioxin-like PCBs with dioxins and furans to evaluate potential noncancer effects may be inappropriate, contributes uncertainty to the hazard estimates, and would make it likely that the endpoint-specific noncancer effects of TEQ<sub>DFP</sub> would be overestimated.

### **5.2.5 Summary and Conclusions: Baseline Human Health Risk Assessment for the Area North of I-10 and Aquatic Environment**

USEPA (1989) describes a human health risk assessment as a quantitative evaluation of the risk posed to human health by the actual or potential presence of chemicals in the environment. A risk assessment provides a conservative estimate of the likelihood of potential health effects in a specific hypothetical population that conforms to stated exposure assumptions, but it is a limited tool because it does not directly measure or predict the occurrence of any actual health effects in people who actually visit or use a site. The results of the risk assessment are intended to help site managers determine when remedial action is needed; determine health-protective levels of chemicals that may remain after remedial actions are completed; provide a basis for comparing the health impacts of remedial alternatives; and provide a consistent process for documenting risks (USEPA 1989).

For this BHHRA, risks were characterized for three hypothetical receptor groups: recreational fishers, subsistence fishers, and recreational visitors. The exposure media evaluated in the risk assessment were sediments in four individual beach areas, soils throughout the entire area of the northern impoundments and edible fish and shellfish that could be captured within USEPA's Preliminary Site Perimeter (i.e., hardhead catfish, clams, and crabs). For each receptor group, this BHHRA evaluated the potential for exposure to COPCHS in media within USEPA's Preliminary Site Perimeter, and the possibility that adverse health effects could occur as a result of assumed long-term exposures to these media under baseline conditions (i.e. immediately prior to the TCRA). The evaluation was completed for a series of different hypothetical scenarios that address direct contact in different areas or ingestion of different types of tissue from within USEPA's Preliminary Site Perimeter. In order to provide perspectives meaningful for comparing remedial alternatives,

incremental risks from background, and reductions in risk resulting from completion of the TCRA, were also evaluated.

The parameters used for evaluating potential exposures and estimating risks and hazards relied on multiple conservative assumptions, which enhance the likelihood that potential assumed exposures and estimated risks are overestimated. The key findings of this BHHRA and conclusions about the potential health risks are summarized below.

Of the COPCHS identified for evaluation in this BHHRA for the area north of I-10 and the aquatic environment, dioxins and furans were identified as a risk driver in all media evaluated for the area north of I-10 and the aquatic environment. PCBs in fish and shellfish tissue, and methylmercury in catfish tissue were additionally identified as COPCHS that contributed substantially to potential risks associated with the area under study.

The results of this BHHRA generally indicate that hypothetical fishing and recreational exposure scenarios that assume direct contact with sediment within the original 1966 perimeter of the northern impoundments (i.e., termed “Beach Area E” throughout this risk assessment) under baseline conditions (i.e., immediately prior to the TCRA) would result in higher potential exposures to risk driving COPCHS, than fishing and recreational scenarios elsewhere within the area under study.

To aid in the presentation of results in a manner useful for risk management, the results of the risk assessment are summarized in two sections below. First, the results for scenarios that assumed exposure to sediments at Beach Area E, together with consumption of fish or shellfish from the adjacent FCA, or soils from north of I-10 are summarized. Second, a summary of results for scenarios that assumed exposure to sediments at other areas (i.e., outside of the 1966 impoundment perimeter (termed Beach Area A, Beach Area B/C, and Beach Area D) in combination with consumption of fish or shellfish from adjacent FCAs or soils is presented.

#### **5.2.5.1 Hypothetical Scenarios with Exposure at Beach Area E**

Three types of hypothetical receptors—recreational fishers, subsistence fishers, and recreational visitors—with potential exposure to sediments at Beach Area E were evaluated. These scenarios assumed that recreational and subsistence fishers exposed via direct contact with beach sediments also ingested fish or shellfish from the adjacent FCA. Hypothetical recreational visitors who contacted sediments in this area were assumed to also contact soils throughout the study area.

##### **5.2.5.1.1 Noncancer Hazards**

RME noncancer HIs greater than 1 were estimated for hypothetical fishing and recreational scenarios that assume direct contact with sediments at Beach Area E. For all three potential receptor groups, regardless of the other media to which they were exposed, assumed direct contact to sediments in Beach Area E accounted for over 98 percent of the RME hazard for reproductive/developmental endpoints<sup>29</sup>. Although the HIs exceeded 1, these results do not necessarily indicate that adverse health effects would have occurred under baseline conditions. The CTE noncancer HIs for all potential receptors in this area were less than 1. The RME estimates relied on a number of highly conservative parameters, including the use of the maximum detected concentration of TEQ<sub>DF</sub> as the EPC for estimating exposure. As a result, a substantial margin of safety was built into the RME estimates for the baseline condition. Completion of the TCRA construction in July, 2011 rendered sediments at Beach Area E inaccessible for direct contact by humans, and is also likely to have led to reductions in tissue concentrations in catfish and clams obtained from this area (although this cannot be confirmed with existing data), substantially reducing any baseline risks in this area.

##### **5.2.5.1.2 Cancer Risks**

All estimated excess cancer risks for potential recreational fishers, subsistence fishers, and recreational visitors who were assumed to contact COPCHS (other than dioxins and furans) in

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<sup>29</sup> Reproductive/developmental endpoints were associated with exposure to dioxins and furans in all media, and methylmercury in catfish. For scenarios that included direct contact with sediments at Beach Area E, the HI for reproductive/developmental endpoints exceeded that for any other noncancer endpoint by more than an order of magnitude.

sediments and soils, and ingest fish or shellfish from the waters within USEPA's Preliminary Site Perimeter were within or below USEPA's target cancer risk range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$ .

#### **5.2.5.1.3 Cancer Hazards**

RME dioxin cancer HIs greater than 1 were estimated for all hypothetical fisher and recreational visitor scenarios that assumed direct contact to sediments at Beach Area E. As was the case for noncancer hazards above, for these potential receptors assumed direct contact to sediment sediments in Beach Area E accounted for over 98 percent of the RME hazard. Although the cancer HIs exceeded 1, these results do not necessarily indicate that cancer effects to the hypothetical fishers and recreational visitors would have occurred under baseline conditions. The CTE cancer HIs for all hypothetical receptors in this area were less than 1, and the RME estimates relied on a number of highly conservative parameters, including the use of the maximum detected concentration of TEQ<sub>DF</sub> as the concentration term for estimating exposure. As a result, a substantial margin of safety was built into the RME estimates. Completion of the TCRA construction in July, 2011 rendered sediments at Beach Area E inaccessible for direct contact by humans, substantially reducing any baseline risks in this area.

#### **5.2.5.2 Scenarios with Exposure at Beach Areas A, B/C, and D**

Three types of potential receptors with exposure to sediments at Beach Areas A, B/C, and D were evaluated. Hypothetical recreational and subsistence fishers exposed via direct contact with sediments at one of the defined beach areas were assumed to also ingest fish or shellfish from the adjacent FCA. Recreational visitors who contact sediments in one of the defined beach areas were assumed to also contact soils throughout the area under study.

##### **5.2.5.2.1 Noncancer Hazards**

This analysis indicated that no adverse noncancer health effects would be expected for hypothetical recreational visitors and recreational fishers as a result of contact with COPCHS in sediments at Beaches A, B/C, or D and soil throughout USEPA's Preliminary Site Perimeter, and consumption of fish or shellfish from the adjacent FCA. RME noncancer HIs for all COPCHS combined for hypothetical recreational fishers were below 1. For hypothetical recreational fishers, RME HIs grouped by toxicity endpoint, were all below 1.

Noncancer HIs greater than 1 occurred only for the hypothetical subsistence fisher under the following scenarios: direct contact to sediments at Beach Area A in combination with ingestion of catfish from the adjacent FCA 2/3; direct contact to sediments at Beach B/C in combination with consumption of either catfish from the adjacent FCA 2/3 or clams from the adjacent FCA 2; and direct contact to sediments at Beach D in combination with consumption of catfish from FCA 1.

For each of these scenarios the predominant pathway of estimated exposure was the consumption of tissue; direct contact with sediments accounted for less than 5 percent of exposure. Potential risk driving COPCHs in tissue were dioxins and furans and PCBs in catfish and clams, and methylmercury in catfish.

Although the noncancer HIs exceeded 1 in these scenarios, these results do not indicate that adverse health effects would have occurred in the hypothetical receptor group under baseline conditions. The RME estimates relied on a number of highly conservative parameters including upper bound consumption rates, the assumption that an individual would obtain 100 percent of the fish or shellfish consumed from the area under study over the entire assumed exposure duration, and the assumption that the concentration of lipophilic compounds would not be reduced through preparation or cooking.

As indicated by the PRA completed for this BHHRA, the influence of variability in estimated consumption rates and the portion of an individual's total consumption obtained from the area under study have large impacts on estimated exposures and resulting hazards for the hypothetical fisher population.

#### **5.2.5.2.2 Cancer Risks**

All estimated excess cancer risks for scenarios that assumed exposures to Beach Areas A, B/C, and D were within or below USEPA's target cancer risk range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$ . These included both RME and CTE cancer risks for the hypothetical recreational fisher, subsistence fisher and recreational visitor scenarios.

#### 5.2.5.2.3 Cancer Hazards

It is not expected that dioxin-related cancer effects would have occurred under the baseline hypothetical recreational visitor and recreational fisher scenarios as a result of assumed contact with dioxins and furans in sediments at Beach Area A, B/C, or D and soil, and consumption of fish or shellfish from within USEPA's Preliminary Site Perimeter. RME cancer TEQ<sub>DF</sub> HIs for these potential receptor groups were all below 1.

RME dioxin cancer HIs greater than 1 were limited to the hypothetical subsistence fisher receptor group under the following assumed scenarios: direct contact with sediments at Beach Area A in combination with ingestion of catfish from the adjacent FCA 2/3; direct contact with sediments at Beach Area B/C in combination with consumption of catfish from the adjacent FCA 2/3; and direct contact with sediments at Beach D in combination with consumption of catfish from FCA 1.

For each of these hypothetical scenarios, consumption of tissue accounted for 95 percent or more of estimated COPCH exposure. Although the cancer HIs exceeded 1, these results do not indicate that cancer effects would have occurred in the hypothetical receptor group under baseline conditions. The RME estimates relied on a number of highly conservative parameters including upper-bound consumption rates, the assumption that an individual obtains 100 percent of the fish or shellfish consumed over the entire exposure duration from waters within USEPA's Preliminary Site Perimeter, and the assumption that concentrations of lipophilic compounds are not reduced during preparation or cooking.

#### 5.2.5.3 Incremental Hazard

Exposure media that contributed the most to estimated human exposure to COPCHs included sediments at Beach Area E, catfish fillet at FCA 2/3 and FCA 1, and clams from FCA 2. However, risk-driving COPCHs present in catfish were also present at elevated concentrations in catfish harvested from background areas designated for this risk assessment. For example, in catfish fillet, 41 to 42 percent of the baseline hazard attributed to TEQ<sub>DF</sub> exposures and 55 to 60 percent of baseline hazard associated with PCBs were also present under background conditions, suggesting that background conditions with respect to these COPCHs contributed roughly one-half of the total potential risks under relevant

scenarios. In addition, the hazards associated with background exposure to methylmercury in catfish fillets were similar to or higher, indicating that any exposures from the study area are not contributing additional risks due to methylmercury.

#### **5.2.5.4 Baseline Versus Post-TCRA Hazards**

As discussed in detail in Appendix F, the post-TCRA noncancer TEQ<sub>DF</sub> HIs for the hypothetical recreational fisher and recreational visitor scenarios are less than 1. For the hypothetical subsistence fisher, the exposure scenarios that assumed consumption of catfish in combination with direct contact to sediment (Scenarios 1A, 2A, and 3A) have post-TCRA RME TEQ<sub>DF</sub> noncancer HIs of 6. These are lower than the baseline HIs, which ranged from 9 to 100, and higher than the background HIs of 4.

The post-TCRA cancer TEQ<sub>DF</sub> HIs are less than 1 for all of the hypothetical recreational fisher and recreational visitor scenarios evaluated. Only the post-TCRA exposure scenarios for the hypothetical subsistence fisher that assumed consumption of catfish in combination with direct contact with sediment result in a RME cancer TEQ<sub>DF</sub> HI of greater than 1 (HI=2). These are lower than baseline cancer TEQ<sub>DF</sub> HIs, which ranged from 3 to 40, and only slightly higher than the background cancer TEQ<sub>DF</sub> HIs of 1 for those scenarios.

The greatest hazard and risk reductions resulting from the TCRA are for baseline scenarios that assumed direct exposure to Beach Area E (Scenarios 3A, 3B, and 3C). This was because the majority of estimated TEQ<sub>DF</sub> exposure and hazard for these scenarios was related to direct contact rather than to the ingestion of fish or shellfish, and because potential exposure to sediment in this area was completely restricted once the TCRA was implemented. For these scenarios, the hazard reductions resulting from TCRA implementation range from 84 to 100 percent. For hypothetical exposure scenarios that assumed direct contact with sediments at Beach Area A, B/C, or D and consumption of catfish or clam from the adjacent FCA, the hazard reductions resulting from the TCRA implementation range from 65 to 86 percent.

The post-TCRA evaluation indicated that the TCRA implementation has substantially reduced potential baseline risks for the area under study. Noncancer and cancer hazards calculated for the hypothetical recreational fisher and recreational visitor scenarios are all

below the target HI of 1 under post-TCRA conditions. While potential noncancer and cancer hazards calculated for the hypothetical subsistence fisher scenario under post-TCRA conditions exceed the target HI of 1, these HIs exceed background levels only by factors of 2 or less.

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## **6 EXPOSURE AND RISK CHARACTERIZATION FOR THE AREA OF INVESTIGATION ON THE PENINSULA SOUTH OF I-10**

This section presents the exposure assessment and risk characterization for the area of investigation on the peninsula south of I-10. The purpose of the exposure assessment (Section 6.1) is to estimate the type and magnitude of potential human exposure to COPCs identified with respect to the area south of I-10 in the context of hypothetical exposure scenarios for a trespasser and a commercial worker. In the risk characterization (Section 6.2), these estimates of exposure are combined with toxicological criteria to yield numerical estimates of potential adverse health effects to a trespasser or to a commercial worker exposed to the extent described by their respective exposure scenarios.

### **6.1 Exposure Assessment**

For the area of investigation south of I-10, exposures were estimated using only deterministic methods. This is because none of the scenarios evaluated in this area resulted in risks that exceeded one or more of the criteria defined for completing a refined analysis (Figure 1-4). The exposure scenarios, algorithms, and assumptions used for the deterministic assessment were established and discussed in the EAM (Appendix A) and are summarized below. This set of assumptions was used for calculating baseline exposures.

#### **6.1.1 Exposure Scenarios**

Two potential receptor groups were defined for the quantitative risk assessment for the area of investigation on the peninsula south of I-10: a commercial worker, and a trespasser. Based on the CSM for this area, the following hypothetical exposure scenarios were evaluated quantitatively:

- Trespasser—direct contact (incidental ingestion and dermal contact) with surface soil.
- Commercial Worker—direct contact (incidental ingestion and dermal contact) with surface and shallow subsurface soils.

In estimating cumulative exposure for each potential receptor group, estimated exposures from the two direct contact pathways (i.e., ingestion and dermal contact) were summed.

#### 6.1.1.1 Exposure Units

An exposure unit is defined in Section 5.1.1.1. For soils in the area of investigation south of I-10 (Figure 6-1), a single exposure unit was defined. This was based on the assumption that individuals trespassing or working in this area could have direct contact with soils in all of the sample collection areas during their visit. Because there is only a single exposure unit for the area of investigation south of I-10, one hypothetical exposure scenario for the commercial worker scenario and one hypothetical exposure scenario for the trespasser were evaluated (Table 5-1).

#### 6.1.2 Estimates of Exposure

This section presents the equations and exposure parameters that were used for estimating potential exposures for the area of investigation south of I-10. Both RME and CTE exposures were estimated.

##### 6.1.2.1 Equations

Two types of exposures were evaluated: 1) ingestion of soil, and 2) dermal contact with soil, as detailed below.

##### Equation 6-1. Intake via Ingestion of Soil

Relevant Receptor Groups: commercial worker and trespasser

$$I_{\text{soil}} = \frac{C_{\text{soil}} \times IR_{\text{soil}} \times RBA_{\text{soil}} \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times CF_1}{BW \times AT} \quad (\text{eq. 6-1})$$

Where:

$I_{\text{soil}}$	=	intake, the mass of a chemical contacted in soil by the receptor per unit body weight per unit time (mg/kg-day)
$C_{\text{soil}}$	=	chemical concentration in soil contacted over the exposure period (i.e., EPC for soil) (mg/kg)

IR <sub>soil</sub>	=	soil ingestion rate (mg/day)
RBA <sub>soil</sub>	=	relative bioavailability adjustment for soil (percent as a fraction)
FI <sub>soil</sub>	=	fraction of total daily soil intake that is site-related (percent as a fraction)
EF <sub>soil</sub>	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF <sub>1</sub>	=	conversion factor (1×10 <sup>-6</sup> kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)

**Equations 6-2 and 6-3. Dermal Absorbed Dose via Contact with Soil**

Relevant Receptor Groups: commercial worker and trespasser

$$DAD_{soil} = \frac{DA_{event} \times SA \times EF_{soil} \times FI_{soil} \times ED \times EV}{BW \times AT} \quad (\text{eq. 6-2})$$

Where:

DAD <sub>soil</sub>	=	dermal absorbed dose from soil (mg/kg-day)
DA <sub>event</sub>	=	absorbed dose per event (mg/cm <sup>2</sup> )
SA	=	skin surface area available for contact (cm <sup>2</sup> )
EV	=	event frequency (day <sup>-1</sup> )

And,

$$DA_{event} = (C_{soil} \times AF_{soil} \times F_{soil}) \times ABS_d \times CF_1 \quad (\text{eq. 6-3})$$

Where:

AF <sub>soil</sub>	=	adherence factor for soil (mg/cm <sup>2</sup> )
ABS <sub>d</sub>	=	dermal absorption factor for soil (percent as a fraction)

### 6.1.2.2 Deterministic Exposure Evaluation

The EPCs and exposure parameters selected for each scenario are summarized below and are discussed in detail in the EAM (Appendix A).

#### **6.1.2.2.1 Exposure Point Concentrations**

EPCs were estimated for surface and subsurface soil according to the procedures outlined in Section 3.2. Table 6-1 summarizes the RME and CTE EPCs used for the deterministic assessment of baseline risks for the area of investigation south of I-10. Supporting documentation for the EPC derivations, including summaries of the best-fit distribution and basic summary statistics for each dataset, is provided as Appendix E.

#### **6.1.2.2.2 Exposure Parameters**

This section provides an overview of the exposure assumptions used in the deterministic evaluation for the area of investigation south of I-10. A detailed presentation and the supporting rationales for these assumptions are included in the EAM (Appendix A) and a summary of these exposure parameters is presented in Table 6-2. Assumptions adopted for chemical-specific exposure parameters are provided in Table 5-7.

##### ***Common Parameters***

For the hypothetical trespasser scenario, it was assumed that the trespasser is a young adult between the ages of 16 and 22 years. For the RME, the assumed exposure duration of 7 years was based on this assumed age group (16 to <23 years). For the CTE exposure, it was assumed that the trespasser visits the area of investigation on the peninsula south of I-10 for approximately one-half of the RME duration or 4 years. Because this area is currently fenced and actively managed for industrial activity, it is reasonable to assume that any activity would be infrequent. Therefore, an exposure frequency of 2 days per month or 24 days per year was assumed to evaluate the RME and 1 day per month or 12 days per year was assumed for the CTE. The mean body weight of 74 kg for males and females age 16 to <23 years was assumed for the trespasser (USEPA 2011a).

Commercial workers were assumed to be adults who perform work activities primarily outside. For the hypothetical commercial worker scenario, USEPA's (2002c) default exposure duration of 25 years was assumed for the RME and 12 years was assumed for the CTE. An exposure frequency of 225 days per year was assumed (USEPA 2002c). Based on USEPA (2011a), the mean body weight of 80 kg for male and female adults was used.

As discussed in Section 5.1.2.2.2, the averaging time depends on the toxic endpoint (cancer or noncancer) being assessed. For noncarcinogens, the averaging time was set equal to the exposure duration (e.g., for the hypothetical trespasser scenario with an assumed exposure duration of 7 years, the averaging time was 2,555 days). For carcinogens that were evaluated with a CSF, the averaging time was set equal to a lifetime (i.e., 78 years or 28,470 days) (USEPA 1989, 2011a). When the toxicity of a carcinogen was described using a criterion that assumes a threshold dose is required for an adverse effect to be elicited (i.e.,  $TEQ_{DF}$ ), then the averaging time was set equal to the exposure duration.

#### ***Parameters for Direct Contact***

To evaluate incidental soil ingestion for the hypothetical trespasser scenario, an age-weighted soil ingestion rate of 41 mg/day was used for both the RME and CTE. This rate was based on USEPA's (2011a) recommended soil ingestion rate of 50 mg/day for individuals ages 6 to <21 years, and 20 mg/day for individuals age 21 and older. If, in fact, an individual does trespass in the area of investigation south of I-10, then it is anticipated that his or her stay would be for only a few hours at most. In addition, any such individuals likely would participate in daily activities at locations other than those locations in the area under study south of I-10 where exposure to soil could occur. In consideration of the likely short duration of daily activity in locations in the area of study compared to activities in other areas, fractional intakes for direct contact with soil of 0.5 and 0.25 were used for the RME and CTE, respectively.

To evaluate dermal contact for the hypothetical trespasser scenario, it was assumed that a trespasser's hands, forearms, lower legs, and feet might come into contact with surface soil. Based on this assumption and on the surface areas for these body parts provided in USEPA (2011a), a total surface area of 5,550 cm<sup>2</sup> was used to evaluate both the CTE and RME. Following USEPA recommendations, a body part-specific weighted adherence factor of 0.07 mg/cm<sup>2</sup> was calculated using data from a study of adults exposed to soil via a variety of soil activities. This adherence factor was used for both the CTE and RME.

For the hypothetical commercial worker scenario, it was assumed that the outdoor workers might be involved in contact-intensive activities. To account for the potentially more

intensive contact, the recommended soil ingestion rate for outdoor workers of 100 mg/day was used for the RME (USEPA 2002c). Because workers might also be involved in less intensive activities, a rate of 50 mg/day was used to evaluate the CTE. This CTE rate is based on the recommended rate from USEPA (2002c) for an indoor worker. Because it is likely that some workers spend a majority of their time outdoors in the area of investigation south of I-10, the fractional daily intake of soil was assumed to be 1.0 for both RME and CTE.

To evaluate dermal contact for the hypothetical commercial worker scenario, it was assumed that a worker's head, forearms, and hands might come into contact with surface and shallow subsurface soil. Based on this assumption and surface areas for these body parts provided in USEPA (2011a), a total surface area of 3,470 cm<sup>2</sup> was used to evaluate both the CTE and RME. Following USEPA (2004) recommendation, a soil adherence factor of 0.2 mg/cm<sup>2</sup> was used and is based on data for a wide variety of activities during which an individual might be in contact with soil. This adherence factor was used for both the CTE and RME.

### ***Chemical-Specific Factors***

In addition to the scenario-specific exposure assumptions described above, there are chemical-specific factors that were required to estimate COPCH-specific exposure levels. Discussion of these chemical-specific factors was presented in Section 5.1.2.2.2 and summarized in Table 5-7. Further discussion of these parameters and the rationales for the values selected is presented in Appendix D.

## **6.2 Risk Characterization**

As discussed in Section 5.2, risk characterization is the final step in the risk assessment process, where the goal is to present and interpret the key findings of the risk assessment, along with their limitations and uncertainties, for use in risk management decision-making. Three categories of health effects were evaluated for this BHHRA: cancer risk, noncancer hazard, and dioxin cancer hazard. Section 5.2.1 presents a general description of the methods used to estimate these potential effects. Very briefly, lifetime cancer risks in excess of background were calculated as the product the LADD and the CSF. Cancer risks in excess of background associated with each COPCH were summed across both of the assumed exposure routes (i.e., ingestion of soil and dermal contact with soil) and then across COPCHs

to estimate overall excess cancer risk associated with potential exposures in the area of investigation on the peninsula south of I-10. Noncancer hazards (i.e., HQs) for each assumed exposure route were calculated as the ratio of the ADD to the RfD. Then the individual HQs for a given COPCH were summed for an individual receptor to derive a COPCH-specific HI. Finally, the COPCH-specific HIs were summed to derive a total HI for that exposure scenario. Consistent with USEPA guidance (1989) in the case that the total HI for a receptor exceeded 1 for all COPCHs combined, separate hazard indices for group of COPCHs that affect the same target organ or endpoint were estimated. These effect-specific HIs provide a more accurate indication of whether there is potential for a specific adverse health effect to occur to the potential receptors.

The carcinogenic potential for TEQ<sub>DF</sub> was estimated using a hazard metric like that described for noncancer hazards above (Appendix B). Cancer hazards due to TEQ<sub>DF</sub> were expressed as an HQ for a single assumed exposure route and an HI when hazards from all assumed exposure routes for a receptor were summed. Because cancer is a different toxic endpoint from the noncancer endpoints, the HIs for dioxin were not summed with noncancer hazards.

### **6.2.1 Baseline Risk Results for the Area of Investigation on the Peninsula South of I-10**

This section presents the baseline deterministic risk results by potential receptor group for the area of investigation on the peninsula south of I-10. A summary of RME and CTE hazards and risks are provided in Table 6-3. The full set of risk and hazard estimates are provided as Appendix J, where Tables J-1 and J-2 present estimated exposures and resulting hazards and risks by exposure pathway and Tables J-3 and J-4 present estimated hazards and risk by exposure scenario.

#### **6.2.1.1 Hypothetical Trespasser**

The assumed exposure routes evaluated for the hypothetical trespasser are incidental ingestion and dermal contact with surface soil throughout the area of investigation south of I-10. Table 6-3 presents a summary of cumulative noncancer hazards, cancer risks, and TEQ<sub>DF</sub> cancer hazards for the trespasser scenario. The noncancer RME HI is 0.006 and the CTE HI is 0.0004. The cumulative RME excess cancer risk is  $2 \times 10^{-7}$  and the CTE cancer risk

is  $9 \times 10^{-9}$ . The RME TEQ<sub>DF</sub> cancer HI for the hypothetical trespasser scenario is 0.0002, while the CTE TEQ<sub>DF</sub> cancer HI is tenfold lower at 0.00002. Overall, for the hypothetical trespasser scenario, noncancer HIs and TEQ<sub>DF</sub> cancer HIs are all less than 1. All estimated cancer risks in excess of background for this scenario were below USEPA's target cancer risk range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$ .

#### **6.2.1.2 Hypothetical Commercial Worker**

Potential exposure routes for hypothetical commercial workers included incidental ingestion and dermal contact with surface and shallow subsurface soil. A single exposure scenario, which assumed direct exposure to soils throughout the area of investigation south of I-10, was evaluated for this potential receptor group.

Table 6-3 presents a summary of cumulative noncancer hazard, cancer risk, and dioxin cancer hazard for the hypothetical commercial worker scenario. The noncancer RME HI is 0.2, while the CTE HI is 0.04. The cumulative RME cancer risk is  $3 \times 10^{-5}$ . Cumulative CTE cancer risk is  $3 \times 10^{-6}$ . The RME TEQ<sub>DF</sub> cancer HI is 0.006, while the estimated CTE TEQ<sub>DF</sub> cancer HI is 0.002. Overall, for the hypothetical commercial worker scenario, noncancer HIs and TEQ<sub>DF</sub> cancer HIs are all less than 1. All estimated excess cancer risks for this scenario are within USEPA's target cancer risk range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$ .

#### **6.2.1.3 Summary of Deterministic Results**

None of the scenarios for the area of investigation south of I-10 have estimated cancer risks greater than  $1 \times 10^{-4}$ , endpoint-specific HIs greater than 1, or dioxin cancer HIs greater than 1. Consistent with the approach for this BHHRA presented in Figure 1-4, no refined analyses were completed for these scenarios.

### **6.2.2 Uncertainty Analysis**

Risk characterization should present information important to interpreting risks in order to place the risk estimates in proper perspective. Uncertainties exist in each step of the risk assessment process, including the data collection and analysis, the estimation of potential exposures, and toxicity assessment. This section discusses the significant sources of uncertainty for the analysis.

#### **6.2.2.1      *Uncertainties in Data Treatment***

Some uncertainty is introduced with the data rules applied in the calculation of EPCs. Following the data rules established for this assessment, TEQ<sub>DF</sub> was calculated in two ways. First, individual congeners that were not detected in a sample were estimated to be present at one-half of the detection limit of that individual congener. Second, congeners that were not detected were treated as zero. The impact of the decision on the resulting TEQ<sub>DF</sub> is dependent on both the number of congeners that were not detected and the detection limits for the congeners that were not detected. By comparing the resulting EPCs calculated using these two approaches, the impact of the uncertainty was determined. The difference in the EPCs for TEQ<sub>DF</sub> applying one-half the detection limit to TEQ<sub>DF</sub> applying zero were less than three percent (Table 6-1). Therefore, any uncertainty introduced by the treatment of non-detects does not substantially influence the risk results.

#### **6.2.2.2      *Uncertainties in Exposure Estimates***

Minor exposure pathways that were not evaluated quantitatively include the inhalation of entrained dust derived from soil, and inhalation of volatile compounds present in soil. Generally, risks due to the inhalation of entrained dust originating from soils are orders of magnitude lower than risks due to direct contact pathways (USEPA 2012a). Therefore, their contribution to overall risks associated with the trespasser and commercial worker scenarios is minimal. While inhalation of volatiles, if present, can contribute to total risk, none of the COPCHS identified is considered to be volatile.

There are also some uncertainties associated with some of the assumptions used for estimating potential exposure via direct contact. For the area of investigation south of I-10, these primarily include assumptions about exposure pattern and frequency for the hypothetical trespasser. The nature of trespassing is such that the activity is not expected to occur on a daily basis. The exposure frequency of 24 days or twice a month over the course of a year is a reasonable assumption. However, it is possible that trespassing activity could occur at a greater frequency. Even if a trespasser visited the area one day per week throughout the year, over the course of the exposure duration (i.e., 7 years for RME), risks and hazards would not exceed the risk thresholds set by USEPA of  $1 \times 10^{-4}$  and 1, respectively.

### **6.2.2.3      *Uncertainties in Toxicity Evaluation***

The toxicity criterion that was used to evaluate potential cancer effects due to dioxins and furans (i.e., as TEQ<sub>DF</sub>) was the TDI of 2.3 pg/kg-day derived from JECFA (2002). This TDI was developed based on the assumption that the cancer dose-response for TCDD and other DLCs is not linear and that there is a threshold for the carcinogenic effects of these compounds. There is substantial support for using a threshold approach to evaluate DLCs (WHO 1991, 1992, 1998; JECFA 2002; Simon et al. 2009; NAS 2006; ACC 2010; TCEQ 2010a,b, 2011; Haney 2010).

As discussed in Section 4.3.1, Section 5.2.4.3.1, and Appendix B, USEPA has been conducting its dioxin reassessment for nearly 20 years. While the scientific consensus during that period has been growing to conclude that DLCs act via a non-linear dose response, USEPA's most recent report on its reassessment indicates that it continues to assume that TCDD acts as a non-threshold carcinogen. Table 5-24 provides a summary of key toxicological criteria that have been developed by regulatory agencies and the scientific community for TCDD. These criteria are discussed in Section 5.2.4.3.1, and include criteria based on threshold and non-threshold (i.e., linear) models. Table 5-24 also presents RsD<sup>30</sup> derived using the CSFs. These RsDs can be compared to threshold based doses for cancer in order to provide perspective on the impact of different toxicity criteria on the risk results. Using the various CSFs results in RsDs ranging from 0.64 to 11 pg/kg-day when considering upper-bound Tier 3 CSFs ranging from 9,000 to 156,000 (mg/kg-day)<sup>-1</sup>. The LADD for the hypothetical trespasser and commercial worker receptors evaluated are all below 0.64 pg/kg-day (Appendix J, Tables J-1 and J-2). Therefore, if excess cancer risk had been calculated for these scenarios using any Tier 3 CSF, then the results would be below USEPA's threshold of  $1 \times 10^{-4}$ . The ADD for these receptors were all below the values derived assuming that DLCs act as threshold carcinogens (i.e., 1 to 100 pg/kg-day). Based on this comparison, regardless of the Tier 3 toxicity criterion used, potential exposures to dioxins and furans in the area of investigation south of I-10 are not anticipated to present cancer risks that exceed the upper end target risk threshold established by USEPA.

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<sup>30</sup> The RsDs presented are based on a target risk level of  $1 \times 10^{-4}$ .

In addition, there are substantial uncertainties associated with USEPA's recently published RfD of 0.7 pg/kg-day for TCDD, which was used to evaluate the noncancer effects of DLCs in this BHHRA. This RfD was based on studies conducted by Baccarelli et al. (2008) and Mocarelli et al. (2008). Both evaluated health effects in human populations that were exposed to dioxins and furans as the result of a trichlorophenol reactor accident that occurred in 1976 in Seveso, Italy (USEPA 2012b). While this RfD has been adopted by USEPA, a number of questions arose during its peer review pertaining to the selection of appropriate NOAELs, pharmacokinetic consideration of increased elimination rates in children, correction for exposures to other dioxins and furans, and the full weight of evidence provided by other human and animal studies (SAB 2011; ACC 2010; Foster et al. 2010).

Differing values for noncancer effects have also been developed by other agencies worldwide. These are discussed above in Section 5.2.4.3.1 and Appendix B, and range from 1 to 4 pg/kg-day (DeRosa et al. 1999; Pohl et al. 2002; JECFA 2002). If any of these noncancer criteria were used to estimate noncancer effects in place of USEPA's recently published RfD of 0.7 pg/kg-day, the resulting noncancer hazards would be lower than those estimated and presented above (Table 6-3).

### **6.2.3     *Summary and Conclusions: Baseline Human Health Risk Assessment for the Area of Investigation on the Peninsula South of I-10***

For the area of investigation on the peninsula south of I-10, risks were characterized for two potential receptor groups: trespassers and commercial workers. The exposure medium evaluated for this area was soil. For each scenario, potential exposures were evaluated via direct contact with soil (i.e., ingestion and dermal contact). For both the hypothetical commercial worker and trespasser scenarios, all cumulative risks are below  $1 \times 10^{-4}$  and noncancer and dioxin cancer hazards are below 1. The parameters used for evaluating potential exposures and estimating risks and hazards relied on multiple conservative assumptions, which enhance the likelihood that potential assumed exposures and estimated risks are overestimated.

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## TABLES

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**Table 1-1**  
**Chemicals of Potential Concern for Human Health for the Area**  
**North of I-10 and Aquatic Environment**

<b>COPC<sub>H</sub></b>
<b>Dioxins and Furans</b>
Dioxins and Furans
<b>Metals</b>
Arsenic
Cadmium
Chromium
Copper
Mercury
Nickel
Zinc
<b>Polychlorinated Biphenyls</b>
Polychlorinated Biphenyls
<b>Semivolatile Organic Compounds</b>
Bis(2-ethylhexyl)phthalate

**Notes**

COPC<sub>H</sub> = chemical of potential concern for human health

**Table 1-2**

**Chemicals of Potential Concern for Human Health for the  
Area of Investigation on the Peninsula South of I-10**

<b>COPC<sub>H</sub></b>
<b>Dioxins and Furans</b>
Dioxins and Furans
<b>Metals</b>
Arsenic
<b>Semivolatile Organic Compounds</b>
Benzo(a)pyrene

**Notes**

COPC<sub>H</sub>= chemical of potential concern for human health

**Table 3-1**  
**Baseline Human Health Risk Assessment Data<sup>a</sup>**

Area and Medium	Study/Dataset	Sampling Period	Description of Samples Relevant for Human Health <sup>a</sup>	COPCs Evaluated
<b>Data for Area North of I-10 and Aquatic Environment</b>				
Sediment	URS 2010 (collected by TCEQ in 2009)	8/2009	Surface samples (0- to 6-inch) in the shoreline area around the northern impoundment.	Dioxins and furans
	Remedial Investigation (TCRA)	4/2010	Surface samples (0- to 6-inch) in the northern impoundment.	Dioxins and furans
	Remedial Investigation	5/2010-6/2010 and 10/2010	Surface samples (0- to 6-inch) collected from five beach areas to evaluate human exposure. Additional surface samples (0- to 6-inch) collected within the shoreline area of the northern impoundment.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors and dioxin-like congeners), BEHP
Soil	Remedial Investigation (TxDOT ROW)	8/2010	Surface samples (0- to 6-inch; 0- to 8-inch; 0- to 12-inch) collected alongside I-10.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors and dioxin-like congeners), BEHP
	Remedial Investigation (TCRA BSS)	11/2010	Surface samples (0- to 6-inch) collected to the west of the northern impoundment.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors), BEHP
	Remedial Investigation (Groundwater study)	12/2010–1/2011	Surface samples (0- to 6-inch) collected in the area between I-10 and the northern impoundment.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, BEHP
	Remedial Investigation	2/2011	Surface samples (0- to 6-inch) collected throughout the area north of I-10.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, BEHP
Tissue	University of Houston and Parsons (2009)	5/2008, 8/2008, 5/2009	Atlantic croaker fillet (skin removed), Blue catfish fillet, and Hardhead catfish fillet (skin removed) from a single location within FCA 1.	PCBs (congeners)
	Remedial Investigation	10/2010	Hardhead catfish fillet (skin removed), Blue crab (edible tissue) and <i>Rangia cuneata</i> clams (soft tissue) from three FCAs.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (congeners), BEHP
<b>Data for Area of Investigation on the Peninsula South of I-10</b>				
Soil	Remedial Investigation (Phase I)	3/2011	Co-located surface and shallow subsurface samples (0- to 6-inch, 6- to 12-inch) collected at a subset of locations. Deeper surface samples (0 to 2-feet) collected at a subset of locations.	TEQ <sub>DF</sub> , arsenic, benzo(a)pyrene
	Remedial Investigation (Phase II)	5/2012	Co-located surface and shallow subsurface samples (0- to 6-inch, 6- to 12-inch).	TEQ <sub>DF</sub> , arsenic, benzo(a)pyrene
<b>Background Data</b>				
Sediment	Remedial Investigation	5/2010, 8/2010, and 10/2011	Surface samples (0- to 6-inch) collected upstream of the Site.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors and dioxin-like congeners), BEHP
Soil	Remedial Investigation	2/2011	Co-located surface and shallow subsurface samples (0- to 6-inch, 6- to 12-inch) collected from two public parks.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, BEHP

**Table 3-1**  
**Baseline Human Health Risk Assessment Data<sup>a</sup>**

Area and Medium	Study/Dataset	Sampling Period	Description of Samples Relevant for Human Health <sup>a</sup>	COPC <sub>h</sub> s Evaluated
Tissue	University of Houston and Parsons (2009)	5/2008–8/2008, 5/2009	Hardhead catfish fillet collected downstream of the Site (locations downstream of the Fred Hartman bridge and additional samples located approximately 1,000 feet upstream of the Fred Hartman Bridge).	PCBs (congeners)
	Remedial Investigation	10/2010 and 10/2011	Hardhead catfish fillet (skin removed), blue crab (edible) collected downstream of the Site; <i>Rangia cuneata</i> clams (soft tissue) collected from an upstream area.	Dioxins and furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (congeners), BEHP

**Notes**

BEHP = bis(2-ethylhexyl)phthalate  
 BHHRA = baseline human health risk assessment  
 COPC<sub>h</sub> = chemical of potential concern for human health  
 FCA = fish collection area  
 PCB = polychlorinated biphenyl  
 TCRA = time critical removal action  
 TCEQ = Texas Commission on Environmental Quality  
 TxDOT ROW = Texas Department of Transportation right-of-way

a - All data for the BHHRA was of Category 1 data validation. Only data from representative sample locations and depths to evaluate human exposures are described.

**Table 3-2**  
**Mammalian Toxicity Equivalency Factors for PCDDs, PCDFs, and PCBs**

Compound	TEF
<b>PCDDs</b>	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
All HxCDDs	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
<b>PCDFs</b>	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
All HxCDFs	0.1
All HpCDFs	0.01
OCDF	0.0003
<b>PCBs</b>	
3,3',4,4'-Tetrachlorinated biphenyl (PCB-77)	0.0001
3,4,4',5-Tetrachlorinated biphenyl (PCB-81)	0.0003
3,3',4,4',5-Pentachlorinated biphenyl (PCB-126)	0.1
3,3',4,4',5,5'-Hexachlorinated biphenyl (PCB-169)	0.03
2,3,3',4,4'-Pentachlorinated biphenyl (PCB-105)	0.00003
2,3,4,4',5-Pentachlorinated biphenyl (PCB-114)	0.00003
2,3',4,4',5-Pentachlorinated biphenyl (PCB-118)	0.00003
2',3,4,4',5-Pentachlorinated biphenyl (PCB-123)	0.00003
2,3,3',4,4',5-Hexachlorinated biphenyl (PCB-156)	0.00003
2,3,3',4,4',5'-Hexachlorinated biphenyl (PCB-157)	0.00003
2,3',4',4',5,5'-Hexachlorinated biphenyl (PCB-167)	0.00003
2,3,3',4,4',5,5'-Heptachlorinated biphenyl (PCB-189)	0.00003

**Source**

Van den Berg et al. (2006)

**Notes**

PCB = polychlorinated biphenyl

PCDD = polychlorinated dibenzo-*p*-dioxin

PCDF = polychlorinated dibenzofuran

TEF = toxicity equivalency factor

TCDD/TCDF = tetrachlorinated dibenzo dioxins/furans

PeCDD/PeCDF = pentachlorinated dibenzodioxins/furans

HxCDD/HxCDF = hexachlorinated dibenzodioxins/furans

HpCDD/HpCDF = heptachlorinated dibenzodioxins/furans

OCDD/OCDF = octachlorinated dibenzodioxins/furans

**Table 3-3**  
**PCB Congeners for Inclusion in Total PCB Summation**

PCB-8	PCB-81	PCB-128	PCB-177
PCB-18	PCB-87	PCB-138	PCB-180
PCB-28	PCB-99	PCB-151	PCB-183
PCB-37	PCB-101	PCB-153	PCB-187
PCB-44	PCB-105	PCB-156	PCB-189
PCB-49	PCB-110	PCB-157	PCB-194
PCB-52	PCB-114	PCB-158	PCB-195
PCB-66	PCB-118	PCB-167	PCB-201
PCB-70	PCB-119	PCB-168	PCB-206
PCB-74	PCB-123	PCB-169	PCB-209
PCB-77	PCB-126	PCB-170	

**Notes**

PCB = polychlorinated biphenyl

**Table 4-1**  
**Toxicological Criteria for Cancer**

<b>Chemical of Potential Concern</b>	<b>Provisional Tolerable Oral Daily Intake/Oral Cancer Slope Factor</b>	<b>Units</b>	<b>USEPA Weight of Evidence/ Cancer Guideline Description</b>	<b>Date of Most Recent Update</b>
2,3,7,8-TCDD <sup>a</sup>	2.3	pg/kg-day	B2	2002
Polychlorinated biphenyls	2 (upper); 1 (central) <sup>b</sup>	(mg/kg-day) <sup>-1</sup>	B2	6/1/1997
Bis(2-ethylhexyl)phthalate	0.014	(mg/kg-day) <sup>-1</sup>	B2	2/1/1993
Benzo(a)pyrene	7.3	(mg/kg-day) <sup>-1</sup>	B2	11/1/1994
Arsenic (inorganic)	1.5	(mg/kg-day) <sup>-1</sup>	A	4/10/1998
Cadmium	--	--	B1 (inhalation only)	6/1/1992
Chromium(III)	--	--	D	9/3/1998
Chromium(VI)	--	--	D (oral)	9/3/1998
Copper	--	--	D	8/1/1991
Nickel	--	--	Not evaluated	8/1/1994
Methylmercury	--	--	C	5/1/1995
Mercury (inorganic)	--	--	D	5/1/1995
Zinc	--	--	D	8/3/2005

**Notes**

-- = no value available

TCDD = tetrachlorinated dibenzo dioxin

USEPA = U.S. Environmental Protection Agency

a - This value used to evaluate the summed toxic equivalents of 2,3,7,8-substituted dioxins; 2,3,7,8-substituted furans; and dioxin-like polychlorinated biphenyl congeners. It is based on the JECFA (2002) recommended provisional tolerable monthly intake for all potential health effects including cancer, adjusted to reflect a daily intake (see text.)

b - USEPA's IRIS database provides both an upper bound and a central tendency cancer slope factor for polychlorinated biphenyls. These were used for the reasonable maximum exposure and central tendency exposure risk calculations, respectively.

**Table 4-2**  
**Toxicological Criteria for Noncancer Effects**

Chemical of Potential Concern	Chronic Oral RfD Value	Units	Sources of Chronic RfD	Combined Uncertainty/Modifying Factors: Chronic	Subchronic Oral RfD Value	Sources of Subchronic RfD (Target Organ)	Combined Uncertainty/Modifying Factors: Subchronic	Primary Target Organ	Dates of Most Recent Update <sup>a</sup>
2,3,7,8-TCDD and DLCs	0.7	pg/kg-day	IRIS	30	0.7	IRIS <sup>b</sup>	30	Thyroid/sperm count and motility	2/17/2012
Polychlorinated biphenyls (Aroclor 1254) <sup>c</sup>	2×10 <sup>-5</sup>	mg/kg-day	IRIS	300	6×10 <sup>-5</sup>	calculated <sup>d</sup>	100	Immune system	11/1/1996
Polychlorinated biphenyls (Aroclor 1016)	7×10 <sup>-5</sup>	mg/kg-day	IRIS	100	2×10 <sup>-4</sup>	calculated <sup>d</sup>	-	Reproductive/developmental	11/1/1996
Bis(2-ethylhexyl)phthalate	0.02	mg/kg-day	IRIS	1,000	0.6	calculated <sup>d</sup>	300	Liver	5/1/1991
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--
Arsenic (inorganic)	3×10 <sup>-4</sup>	mg/kg-day	IRIS	3	3×10 <sup>-4</sup>	IRIS <sup>b</sup>	-	Hyperpigmentation, keratosis, possible vascular	2/1/1993
Arsenic (organic)	0.01	mg/kg-day	ATSDR	100	0.1	ATSDR (diarrhea) <sup>e</sup>	100	Kidney	8/1/2007
Cadmium	0.001	mg/kg-day	IRIS	10	0.001	IRIS <sup>b</sup>	-	Kidney	2/1/1994
Chromium(III)	1.5	mg/kg-day	IRIS	1,000	1.5	IRIS <sup>b</sup>	-	No effects	9/3/1998
Chromium(VI)	0.003	mg/kg-day	IRIS	900	0.008	calculated <sup>d</sup>	300	No effects	9/3/1998
Copper	0.04	mg/kg-day	HEAST	NA	0.04	HEAST <sup>b</sup>	-	Gastrointestinal system	7/3/1997
Nickel	0.02	mg/kg-day	IRIS	300	0.02	IRIS <sup>b</sup>	-	Decreased organ and body weight	12/1/1996
Mercury (inorganic)	3×10 <sup>-4</sup>	mg/kg-day	IRIS	1,000	3×10 <sup>-3</sup>	calculated <sup>d</sup>	100	Autoimmune effects	5/1/1995
Methylmercury	1×10 <sup>-4</sup>	mg/kg-day	IRIS	10	1×10 <sup>-4</sup>	IRIS <sup>b</sup>	-	Neuropsychological	7/27/2001
Zinc	0.3	mg/kg-day	IRIS	3	0.3	IRIS <sup>b</sup>	-	Decrease in ESOD activity	8/3/2005

**Notes**

-- = no value available

ATSDR = Agency for Toxic Substances and Disease Registry

DLCs = dioxin-like compounds

ESOD = erythrocyte Cu/Zn superoxide dismutase

HEAST = Health Effects Assessment Summary Tables

IRIS = Integrated Risk Information System

NA = Information not available in HEAST

PPRTV = provisional peer reviewed toxicity value

RfD = reference dose

a - Dates for chronic and subchronic values are the same unless otherwise indicated.

b - No subchronic RfD was available. The chronic RfD was selected.

c - The Toxicological and Epidemiological Studies Memorandum (Appendix B) presented IRIS RfD for both Aroclor 1016 and Aroclor 1254. Because Aroclor 1254 was the only Aroclor detected, only the Aroclor 1254 value was used in the BHHRA.

d - Derivation of the chronic RfD included a factor to adjust for less than lifetime exposure. This value was removed to derive the subchronic RfD.

e - Target organ for subchronic toxicity value differs from that for the chronic effect.

**Table 5-1**  
**Exposure Scenarios for the BHHRA**

Scenario		Exposure Unit			
		Sediment EU(s)	Soil EU(s)	Finfish EU(s)	Shellfish EU(s)
Northern Impoundments and Aquatic Environment					
Hypothetical Fisher (Recreational and Subsistence)					
Scenario 1A		Beach Area A	--	Hardhead Catfish: FCA 2/3	--
Scenario 1B		Beach Area A	--	--	Clam: FCA 1/3
Scenario 1C		Beach Area A	--	--	Crab: FCA 2/3
Scenario 2A		Beach Area B/C	--	Hardhead Catfish: FCA 2/3	--
Scenario 2B		Beach Area B/C	--	--	Clam: 2
Scenario 2C		Beach Area B/C	--	--	Crab: FCA 2/3
Scenario 3A		Beach Area E	--	Hardhead Catfish: FCA 2/3	--
Scenario 3B		Beach Area E	--	--	Clam: 2
Scenario 3C		Beach Area E	--	--	Crab: FCA 2/3
Scenario 4A		Beach Area D	--	Hardhead Catfish: FCA 1	
Scenario 4B		Beach Area D	--	--	Clam: FCA 1/3
Scenario 4C		Beach Area D	--	--	Crab: FCA 1
Hypothetical Recreational Visitor					
Scenario 1		Beach Area A	Soils North of I-10	--	--
Scenario 2		Beach Area B/C	Soils North of I-10	--	--
Scenario 3		Beach Area E	Soils North of I-10	--	--
Scenario 4		Beach Area D	Soils North of I-10	--	--
Area of Investigation on the Peninsula South of I-10					
Hypothetical Trespasser					
Scenario 1		--	Area of Investigation on the Peninsula South of I-10	--	--
Hypothetical Commercial Worker					
Scenario 1		--	Area of Investigation on the Peninsula South of I-10	--	--

**Notes**

-- = Not applicable, see CSM and refined conceptualization of potential exposure pathways presented in Section 4 of the text.

BHHRA = baseline human health risk assessment

CSM = conceptual site model

EU = exposure unit

FCA = fish collection area

**Table 5-2**  
**Exposure Point Concentrations for Baseline Sediment**

COPC <sub>H</sub>	Beach Area A		Beach Area B/C		Beach Area D		Beach Area E	
	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)
<b>Dioxins and Furans</b>								
TEQ <sub>DF</sub> (ND = 1/2DL)	4.56E-07	3.10E-07	6.36E-06	4.09E-06	2.12E-06	1.42E-06	1.30E-02	9.10E-04
TEQ <sub>DF</sub> (ND = DLO)	3.39E-07	1.98E-07	6.12E-06	3.77E-06	2.00E-06	1.30E-06	1.30E-02	8.80E-04
<b>Metals</b>								
Arsenic	0.3	0.2	2.52	1.59	2.43	1.93	1.9	1.7
Cadmium	0.1	0.1	0.214	0.082	0.431	0.334	1.6	0.299
Chromium	0.83	0.6	21.7	8.10	11.3	5.98	16	8.03
Copper	3.5	0.812	7	5.7	7.88	5.84	57.5	16.1
Mercury	0.0104	0.0059	0.02	0.01	0.04	0.02	2	0.2
Nickel	0.377	0.315	8.80	5.17	6.5	5.41	9.33	7.09
Zinc	8.61	3.35	48.1	24.7	45.8	29.9	222	64.7
<b>Polychlorinated Biphenyls</b>								
Sum of Aroclors <sup>b</sup>	--	--	--	--	--	--	1.40	0.56
Sum of Aroclors (ND = DLO) <sup>b</sup>	--	--	--	--	--	--	0	0
TEQ <sub>p</sub> (ND = 1/2DL)	--	--	--	--	--	--	4.50E-06	2.99E-06
TEQ <sub>p</sub> (ND = DLO)	--	--	--	--	--	--	2.35E-06	1.61E-06
<b>Semivolatile Organic Compounds</b>								
Bis(2-ethylhexyl)phthalate	0.0095	0.0095	0.0933	0.0237	0.0492	0.0319	0.693	0.212

**Notes**

-- = not applicable; samples were not tested for this analyte

COPC<sub>H</sub> = chemical of potential concern for human health

CTE = central tendency exposure

EPC = exposure point concentration

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = nondetects set at zero

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>p</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

a - CTE EPCs are mean values and RME EPCs are the lower of upper confidence limit and maximum values (see Appendix E).

b - Because of matrix interferences that resulted in elevated detection limits, analytical results for Aroclor 1254 were used; see main text for further discussion.

**Table 5-3**  
**Exposure Point Concentrations for Baseline Tissue**

COPC <sub>H</sub>	Hardhead Catfish Fillet				Edible Clam Tissue				Edible Crab Tissue			
	FCA 1		FCA 2/3		FCA 1/3		FCA 2		FCA 1		FCA 2/3	
	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)
<b>Dioxins and Furans</b>												
TEQ <sub>DF</sub> (ND = 1/2DL)	3.92E-06	2.94E-06	4.06E-06	3.58E-06	1.65E-06	1.27E-06	1.90E-05	4.42E-06	1.07E-06	7.39E-07	2.86E-07	1.64E-07
TEQ <sub>DF</sub> (ND = DLO)	3.86E-06	2.88E-06	3.99E-06	3.51E-06	1.51E-06	1.09E-06	2.14E-05	3.91E-06	9.72E-07	5.99E-07	1.76E-07	6.17E-08
<b>Metals</b>												
Arsenic	0.564	0.484	0.665	0.389	0.523	0.491	0.586	0.546	0.521	0.466	0.459	0.426
Cadmium	0.00238	0.000925	0.00103	0.000678	0.0268	0.0253	0.0294	0.0274	0.0244	0.0148	0.0201	0.0103
Chromium	0.0926	0.033	0.0347	0.027	0.201	0.169	0.221	0.159	0.0629	0.047	0.0261	0.00981
Copper	0.509	0.344	0.28	0.265	3.37	2.29	4.02	2.63	13.8	11.1	11.1	10.4
Mercury	0.19	0.159	0.143	0.0908	0.0128	0.0111	0.0114	0.00961	0.0577	0.0527	0.0379	0.0339
Nickel	0.0612	0.027	0.032	0.0186	1.58	1.39	1.3	1.18	0.054	0.042	0.0675	0.0348
Zinc	29.4	19.8	18	16.4	10.6	9.74	11.4	10.8	51.6	50.4	50	47.6
<b>Polychlorinated Biphenyls</b>												
Sum of 43 Congeners - 1/2DL	0.104	0.0848	0.0942	0.083	0.0217	0.0193	0.0500	0.026	0.00335	0.00116	0.00717	0.00471
Sum of 43 Congeners - DLO	0.104	0.0848	0.0942	0.083	0.0216	0.0192	0.0500	0.026	0.00329	0.00108	0.00713	0.00466
TEQ <sub>P</sub> (ND = 1/2DL)	1.67E-06	1.38E-06	1.57E-06	1.32E-06	3.46E-07	2.93E-07	8.24E-07	4.10E-07	1.48E-07	1.19E-07	2.96E-07	1.65E-07
TEQ <sub>P</sub> (ND = DLO)	1.43E-06	1.04E-06	2.38E-06	6.96E-07	8.02E-08	6.6E-08	4.42E-07	1.42E-07	2.01E-08	6.49E-09	1.86E-07	6.65E-08
<b>Semivolatile Organic Compounds</b>												
Bis(2-ethylhexyl)phthalate	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105

**Notes**

COPC<sub>H</sub> = chemical of potential concern for human health

CTE = central tendency exposure

EPC = exposure point concentration

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = nondetects set at zero

FCA = fish collection area

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

a - CTE EPCs are mean values and RME EPCs are the lower of upper confidence limit and maximum values (see Appendix E).

**Table 5-4**  
**Exposure Point Concentrations for Baseline Soils in the Area North of I-10**

<b>COPC<sub>H</sub></b>	<b>RME<sup>a</sup> (mg/kg)</b>	<b>CTE<sup>a</sup> (mg/kg)</b>
<b>Dioxins and Furans</b>		
TEQ <sub>DF</sub> (ND = 1/2DL)	2.26E-05	4.53E-06
TEQ <sub>DF</sub> (ND = DL0)	2.38E-05	4.18E-06
<b>Metals</b>		
Arsenic	3.8	2
Cadmium	0.54	0.11
Chromium	21	7.7
Copper	29.7	8.24
Mercury	3	0.7
Nickel	18	5.8
Zinc	220	45
<b>Polychlorinated Biphenyls</b>		
Sum of Aroclors	0.0484	0.0329
Sum of Aroclors (ND = DL0)	0.0484	0.0329
TEQ <sub>P</sub> (ND = 1/2DL)	2.65E-06	5.41E-07
TEQ <sub>P</sub> (ND = DL0)	2.83E-06	2.26E-07
<b>Semivolatile Organic Compounds</b>		
Bis(2-ethylhexyl)phthalate	0.22	0.036

**Notes**

COPC<sub>H</sub> = chemical of potential concern for human health

CTE = central tendency exposure

EPC = exposure point concentration

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DL0 = nondetects set at zero

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

a - CTE EPCs are mean values and RME EPCs are the lower of upper confidence limit and maximum values (see Appendix E).

**Table 5-5**  
**Exposure Point Concentrations for Background Conditions**

	Sediment		Catfish Fillet		Edible Clam Tissue		Edible Crab Tissue		Soils	
COPC <sub>H</sub>	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)	RME <sup>a</sup> (mg/kg)	CTE <sup>a</sup> (mg/kg)
<b>Dioxins and Furans</b>										
TEQ <sub>DF</sub> (ND = 1/2DL)	6.07E-07	4.00E-07	1.65E-06	4.74E-07	4.70E-07	3.64E-07	1.83E-07	1.26E-07	8.15E-06	3.12E-06
TEQ <sub>DF</sub> (ND = DLO)	5.13E-07	3.01E-07	4.43E-06	1.21E-07	3.97E-07	1.39E-07	9.20E-08	2.99E-08	7.43E-06	1.12E-06
<b>Metals</b>										
Arsenic	0.967	0.403	0.337	0.290	0.528	0.491	0.955	0.638	4.05	2.19
Cadmium	0.176	0.0909	0.00224	0.000875	0.0138	0.0127	0.00935	0.00542	0.355	0.0914
Chromium	4.82	1.81	0.030	0.014	0.147	0.129	0.0273	0.0215	15.7	7.94
Copper	1.93	1.36	1.78	0.617	1.62	1.46	7.62	7.37	9.83	8.03
Mercury	0.0045	0.00272	0.149	0.126	0.00674	0.00617	0.0231	0.0185	0.0704	0.0337
Nickel	3.93	0.907	0.0218	0.0116	1.39	1.20	0.0465	0.0387	14.7	5.37
Zinc	10.3	4.31	15.9	13.9	10.5	9.82	46.3	45.1	95.6	30.6
<b>Polychlorinated Biphenyls</b>										
Sum of Aroclors	--	--	--	--	--	--	--	--	0.0095	0.0095
Sum of Aroclors (ND = DLO)	--	--	--	--	--	--	--	--	0	0
Sum of 43 Congeners (ND = 1/2DL)	--	--	0.0568	0.0481	0.0119	0.00838	0.00105	0.000916	--	--
Sum of 43 Congeners (ND = DLO)	--	--	0.0568	0.0481	0.0117	0.00804	0.00096	0.000826	--	--
TEQ <sub>P</sub> (ND = 1/2DL)	1.98E-07	1.65E-07	1.65E-06	9.77E-07	2.12E-07	1.81E-07	9.44E-08	8.21E-08	--	--
TEQ <sub>P</sub> (ND = DLO)	1.00E-08	5.00E-09	7.50E-07	2.92E-07	3.84E-08	2.24E-08	5.17E-09	4.23E-09	--	--
<b>Semivolatile Organic Compounds</b>										
Bis(2-ethylhexyl)phthalate	0.0165	0.0108	0.105	0.105	0.105	0.105	0.105	0.105	0.0619	0.0227

**Notes**

-- = not applicable; samples were not tested for this analyte  
COPC<sub>H</sub> = chemical of potential concern for human health  
CTE = central tendency exposure  
ND = 1/2DL = nondetects set at one-half the detection limit  
ND = DLO = nondetects set at zero  
RME = reasonable maximum exposure  
TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans  
TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

a - CTE EPCs are mean values and RME EPCs are the lower of upper confidence limit and maximum values (see Appendix E).

**Table 5-6**  
**Exposure Parameters for Deterministic Evaluation for the Area North of I-10 and Aquatic Environment<sup>a</sup>**

	Abbreviation	Units	Hypothetical Recreational Fisher				Hypothetical Subsistence Fisher			Hypothetical Recreational Visitor			
			RME			CTE	RME			RME			CTE
			Adult	Older Child	Young Child	Adult	Adult	Older Child	Young Child	Adult	Older Child	Young Child	Adult
All Pathways													
Body weight	BW	kg	80	50	19	80	80	50	19	80	50	19	80
Exposure duration	ED	years	16	11	6	12	16	11	6	16	11	6	12
Averaging time - non-carcinogens	ATn	days	5,840	4,015	2,190	4,380	5,840	4,015	2,190	5,840	4,015	2,190	4,380
Averaging time - carcinogens	ATc	days	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470
Ingestion of Fish and Shellfish													
Exposure frequency, fish, shellfish	EF <sub>fish-shellfish</sub>	days/year	365	365	365	365	365	365	365	--	--	--	--
Ingestion rate, fish	IR <sub>fish</sub>	g/day	24	18	14	21	58	45	30	--	--	--	--
Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	1.4	1.0	0.6	1.0	3.8	4.5	2.0	--	--	--	--
Fraction of total fish or shellfish intake that is site-related	FI <sub>fish-shellfish</sub>	% as fraction	0.25	0.25	0.25	0.10	1	1	1	--	--	--	--
Ingestion of Soil and Sediment													
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	39	39	13	104	104	104	104	104	104	52
Ingestion rate, soil	IR <sub>soil</sub>	mg/day	20	50	125	20	20	50	125	20	50	125	20
Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	20	50	125	20	20	50	125	20	50	125	20
Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	1	1	1	1	1	1	0.5	0.5	0.5	0.5
Fraction of total daily soil/sediment intake that is site-related	FI <sub>soil-sed</sub>	% as fraction	1	1	1	0.5	1	1	1	1	1	1	0.5
Dermal Contact with Soil and Sediment													
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	39	39	13	104	104	104	104	104	104	52
Skin surface area	SA	cm <sup>2</sup>	6,080	4,270	3,280	6,080	6,080	4,270	3,280	6,080	4,270	3,280	6,080
Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	0.09	0.07	0.07	0.07	0.09	0.07	0.07	0.09	0.07
Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	4.9	5.1	3.6	4.9	4.9	5.1	3.6	4.9	5.1	3.6	4.9
Fraction of pathway exposure that is soil	F <sub>soil</sub>	% as fraction	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
Fraction of pathway exposure that is sediment	F <sub>sed</sub>	% as fraction	1	1	1	1	1	1	1	0.5	0.5	0.5	0.5
Fraction of total daily soil/sediment intake that is site-related	FI <sub>soil-sed</sub>	% as fraction	1	1	1	0.5	1	1	1	1	1	1	0.5
Event frequency	EV	1/day	1	1	1	1	1	1	1	1	1	1	1

**Notes**

-- = Not applicable; pathway is not evaluated for receptor.

CTE = central tendency exposure

RME = reasonable maximum exposure

a - Chemical-specific parameters, including relative bioavailability, dermal absorption, and reduction due to preparation and cooking factors are shown in Table S-7.

**Table 5-7**  
**Chemical-Specific Exposure Parameters for Deterministic Evaluation**

<b>COPC<sub>H</sub></b>	<b>ABS<sub>d</sub> (% as fraction)</b>	<b>RBA<sub>ss</sub> (% as fraction)</b>	<b>RBA<sub>tissue</sub> (% as fraction)</b>	<b>LOSS (% as fraction)</b>
<b>Dioxins and Furans</b>				
Dioxins and Furans	0.03 <sup>a</sup>	0.5 <sup>b</sup>	1 <sup>c</sup>	0 <sup>c</sup>
<b>Metals</b>				
Arsenic (inorganic)	0.03 <sup>a</sup>	0.5 <sup>b</sup>	1 <sup>c</sup>	0 <sup>c</sup>
Cadmium	0.001 <sup>a</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
Chromium	0.02 <sup>d</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
Copper	1 <sup>c</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
Mercury	0.03 <sup>d</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
Nickel	0.04 <sup>d</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
Zinc	1 <sup>c</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
<b>Polychlorinated Biphenyls</b>				
Polychlorinated Biphenyls	0.14 <sup>a</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>
<b>Semivolatile Organic Compounds</b>				
Benzo(a)pyrene	0.13 <sup>a</sup>	1 <sup>c</sup>	--	--
Bis(2-ethylhexyl)phthalate	0.1 <sup>a</sup>	1 <sup>c</sup>	1 <sup>c</sup>	0 <sup>c</sup>

**Notes**

-- = Not applicable; chemical is not a COPC<sub>H</sub> in this medium

ABS<sub>d</sub> = dermal absorption factor for soil and sediment

COPC<sub>H</sub> = chemical of potential concern for human health

LOSS = chemical reduction due to preparation and cooking

RBA<sub>tissue</sub> = relative bioavailability adjustment for tissue

RBA<sub>ss</sub> = relative bioavailability adjustment for soil and sediment

a - Value is from USEPA (2004).

b - Multiple sources were used to derive this value (see Section 5 text).

c - Conservative default assumption.

d - Value is from CalEPA (2011).

**Table 5-8**  
**Exposure Parameters for Probabilistic Evaluation, Hypothetical Young Child Fisher**

Parameter	Abbreviation	Units	Value Used for Deterministic RME		PRA Distribution	Notes and Sources for PRA Distribution
			Hypothetical Recreational Fisher	Hypothetical Subsistence Fisher		
All Pathways						
Body weight	BW	kg	19	19	Lognormal; mean 17.27, std dev 4.97, min 4.4, max 52.4	Portier et al. 2007; USEPA 2011a
Exposure duration	ED	yr	6	6	Triangular; most likely 3.5, min 1, max 6	Best professional judgment
Ingestion of Fish and Shellfish						
Exposure frequency; fish, shellfish	EF <sub>fish-shellfish</sub>	days/yr	365	365	Point estimate 365	IR <sub>fish</sub> and IR <sub>shellfish</sub> assume 365 day exposure
Ingestion rate, fish	IR <sub>fish</sub>	g/day	14	30	Custom; sampled directly from source dataset	Alcoa 1998; USEPA 2011a
Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	0.6	2.0	Custom; sampled directly from source dataset	Alcoa 1998; USEPA 2011a
Fraction of total fish or shellfish intake that is site-related	FI <sub>fish-shellfish</sub>	% as fraction	0.25	1	Triangular; most likely 0.25, min 0.01, max 1	Best professional judgment
Ingestion of Soil and Sediment						
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/yr	39	104	Triangular; most likely 13, min 1, max 156	Best professional judgment
Ingestion rate; soil, sediment	IR <sub>soil-sed</sub>	mg/day	125	125	Lognormal; mean 31, std dev 31, min 0, max 1000	Stanek & Calabrese 1999 & 2001; USEPA 2011a
Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	0	Point estimate 0	
Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	1	Point estimate 1	
Fraction of total daily soil/sediment intake that is site-related	FI <sub>soil-sed</sub>	% as fraction	1	1	Triangular; most likely 1, min 0.5, max 1	Best professional judgment
Dermal Contact with Soil and Sediment						
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/yr	39	104	Triangular; most likely 13, min 1, max 156	Best professional judgment
Exposed skin percentage	ES	% as fraction	--	--	Triangular; most likely 0.311, min 0.143, max 0.541	USEPA 2011a; based on various body parts exposed
Total skin surface area	SA	cm <sup>2</sup>	3,280	3,280	Function of body weight and percent of exposed skin	Burnmaster 1998
Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.09	0.09	Point estimate 0.09	
Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	3.6	3.6	Uniform; min 0.09, max 3.6	Best professional judgment
Fraction of pathway exposure that is soil	F <sub>soil</sub>	% as fraction	0	0	Point estimate 0	
Fraction of pathway exposure that is sediment	F <sub>sed</sub>	% as fraction	1	1	Point estimate 1	
Fraction of total daily soil/sediment intake that is site-related	FI <sub>soil-sed</sub>	% as fraction	1	1	Triangular; most likely 1, min 0.5, max 1	Best professional judgment
Event frequency	EV	1/day	1	1	Point estimate 1	

**Notes**

-- = not applicable; parameter not used in deterministic risk assessment

PRA = probabilistic risk assessment

RME = reasonable maximum exposure

**Table 5-9**  
**Exposure Parameters for Probabilistic Evaluation, Hypothetical Young Child Recreational Visitor**

Parameter	Abbreviation	Units	Value Used for Deterministic RME	PRA Distribution	Notes and Sources for PRA Distribution
<b>All Pathways</b>					
Body weight	BW	kg	19	Lognormal; mean 17.27, std dev 4.97, min 4.4, max 52.4	Portier et al. 2007; USEPA 2011a
Exposure duration	ED	yrs	6	Triangular; most likely 3.5, min 1, max 6	Best professional judgment
<b>Ingestion of Soil and Sediment</b>					
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/yr	104	Triangular; most likely 52, min 1, max 156	Best professional judgment
Ingestion rate; soil, sediment	IR <sub>soil-sed</sub>	mg/day	125	Lognormal; mean 31, std dev 31, min 0, max 1000	Stanek & Calabrese 1999 & 2001; USEPA 2011a
Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0.5	Point estimate 0.5	
Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	0.5	Point estimate 0.5	
Fraction of total daily soil/sediment intake that is site-related	FI <sub>soil-sed</sub>	% as fraction	1	Triangular; most likely 0.5, min 0.1, max 1	Best professional judgment
<b>Dermal Contact with Soil and Sediment</b>					
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/yr	104	Triangular; most likely 52, min 1, max 156	Best professional judgment
Exposed skin percentage	ES	% as fraction	--	Triangular; most likely 0.311, min 0.143, max 0.541	USEPA 2011a; based on various body parts exposed
Total skin surface area	SA	cm <sup>2</sup>	3,280	Function of body weight and percent of exposed skin	Burnmaster 1998
Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.09	Point estimate 0.09	
Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	3.6	Uniform; min 0.09, max 3.6	Best professional judgment
Fraction of pathway exposure that is soil	F <sub>soil</sub>	% as fraction	0.5	Point estimate 0.5	
Fraction of pathway exposure that is sediment	F <sub>sed</sub>	% as fraction	0.5	Point estimate 0.5	
Fraction of total daily soil/sediment intake that is site-related	FI <sub>soil-sed</sub>	% as fraction	1	Triangular; most likely 0.5, min 0.1, max 1	Best professional judgment
Event frequency	EV	1/day	1	Point estimate 1	

**Notes**

-- = not applicable; parameter not used in deterministic risk assessment

PRA = probabilistic risk assessment

RME = reasonable maximum exposure

**Table 5-10**  
**Relative Potential Doses for Reasonable Maximum Exposures by Defined Age Group**

	Relative Ratios of RME ADD by Pathway for Noncancer and Dioxin Cancer Evaluations					
	Fish Ingestion	Shellfish Ingestion	Ingestion of Soil	Ingestion of Sediment	Dermal Contact with Soil	Dermal Contact with Sediment
<b>Hypothetical Recreational Fisher</b>						
Adult	0.41	0.55	--	0.038	--	0.60
Older child	0.49	0.63	--	0.15	--	0.70
Young child	<b>1.0</b>	<b>1.0</b>	--	<b>1.0</b>	--	<b>1.0</b>
Combined	0.54	0.66	--	0.25	--	0.71
<b>Hypothetical Subsistence Fisher</b>						
Adult	0.46	0.45	--	0.038	--	0.60
Older child	0.57	0.86	--	0.15	--	0.70
Young child	<b>1.0</b>	<b>1.0</b>	--	<b>1.0</b>	--	<b>1.0</b>
Combined	0.59	0.69	--	0.25	--	0.71
<b>Hypothetical Recreational Visitor</b>						
Adult	--	--	0.038	0.038	0.34	0.60
Older child	--	--	0.15	0.15	0.38	0.70
Young child	--	--	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Combined	--	--	0.25	0.25	0.48	0.71

**Notes**

bold values indicate the age-group for each receptor group with the greatest potential dose

-- = not applicable; pathway is not complete for this receptor

ADD = average daily dose

RME = reasonable maximum exposure

Table 5-11  
Summary of Baseline Reasonable Maximum Exposure Hazards and Risks for the Area North of I-10 and Aquatic Environment

Scenario	Noncancer HI					Cancer Risk					TEQ <sub>DF</sub> Cancer HI				
	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total	
Hypothetical Recreational Fisher															
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	8E-04	1E-02	2E+00	2E+00		2E-08	3E-07	1E-05	1E-05		7E-05	4E-04	3E-01	3E-01	
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3	8E-04	1E-02	3E-02	4E-02		2E-08	3E-07	3E-07	6E-07		7E-05	4E-04	6E-03	6E-03	
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3	8E-04	1E-02	1E-02	3E-02		2E-08	3E-07	2E-07	5E-07		7E-05	4E-04	1E-03	1E-03	
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	7E-03	6E-02	2E+00	2E+00		1E-07	2E-06	1E-05	1E-05		1E-03	6E-03	3E-01	3E-01	
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	7E-03	6E-02	2E-01	3E-01		1E-07	2E-06	4E-07	3E-06		1E-03	6E-03	7E-02	7E-02	
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3	7E-03	6E-02	1E-02	8E-02		1E-07	2E-06	2E-07	3E-06		1E-03	6E-03	1E-03	7E-03	
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	7E+00	4E+01	2E+00	5E+01		3E-07	9E-06	1E-05	2E-05		2E+00	1E+01	3E-01	1E+01	
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	7E+00	4E+01	2E-01	4E+01		3E-07	9E-06	4E-07	1E-05		2E+00	1E+01	7E-02	1E+01	
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	7E+00	4E+01	1E-02	4E+01		3E-07	9E-06	2E-07	1E-05		2E+00	1E+01	1E-03	1E+01	
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	5E-03	5E-02	2E+00	2E+00		1E-07	2E-06	1E-05	1E-05		3E-04	2E-03	3E-01	3E-01	
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3	5E-03	5E-02	3E-02	8E-02		1E-07	2E-06	3E-07	3E-06		3E-04	2E-03	6E-03	8E-03	
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1	5E-03	5E-02	2E-02	8E-02		1E-07	2E-06	2E-07	2E-06		3E-04	2E-03	4E-03	6E-03	
Hypothetical Subsistence Fisher															
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	2E-03	3E-02	2E+01	2E+01		4E-08	7E-07	1E-04	1E-04		2E-04	1E-03	3E+00	3E+00	
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3	2E-03	3E-02	4E-01	5E-01		4E-08	7E-07	4E-06	5E-06		2E-04	1E-03	8E-02	8E-02	
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3	2E-03	3E-02	2E-01	2E-01		4E-08	7E-07	3E-06	3E-06		2E-04	1E-03	1E-02	1E-02	
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	2E-02	2E-01	2E+01	2E+01		4E-07	6E-06	1E-04	1E-04		3E-03	1E-02	3E+00	3E+00	
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	2E-02	2E-01	3E+00	3E+00		4E-07	6E-06	6E-06	1E-05		3E-03	1E-02	9E-01	9E-01	
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3	2E-02	2E-01	2E-01	4E-01		4E-07	6E-06	3E-06	9E-06		3E-03	1E-02	1E-02	3E-02	
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	2E+01	1E+02	2E+01	1E+02		8E-07	3E-05	1E-04	1E-04		5E+00	3E+01	3E+00	4E+01	
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	2E+01	1E+02	3E+00	1E+02		8E-07	3E-05	6E-06	3E-05		5E+00	3E+01	9E-01	4E+01	
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	2E+01	1E+02	2E-01	1E+02		8E-07	3E-05	3E-06	3E-05		5E+00	3E+01	1E-02	4E+01	
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	1E-02	1E-01	2E+01	2E+01		4E-07	6E-06	1E-04	1E-04		9E-04	5E-03	3E+00	3E+00	
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3	1E-02	1E-01	4E-01	6E-01		4E-07	6E-06	4E-06	1E-05		9E-04	5E-03	8E-02	8E-02	
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1	1E-02	1E-01	3E-01	5E-01		4E-07	6E-06	3E-06	9E-06		9E-04	5E-03	5E-02	5E-02	
	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total
Hypothetical Recreational Visitor															
Scenario 1 - Direct exposure Beach Area A	1E-03	4E-02	1E-02	8E-03	6E-02	2E-08	3E-07	4E-07	8E-08	8E-07	9E-05	5E-03	5E-04	7E-04	6E-03
Scenario 2 - Direct exposure Beach Area B/C	9E-03	4E-02	8E-02	8E-03	1E-01	2E-07	3E-07	3E-06	8E-08	4E-06	1E-03	5E-03	7E-03	7E-04	1E-02
Scenario 3 - Direct exposure Beach Area E	9E+00	4E-02	5E+01	8E-03	6E+01	4E-07	3E-07	1E-05	8E-08	1E-05	3E+00	5E-03	2E+01	7E-04	2E+01
Scenario 4 - Direct exposure Beach Area D	6E-03	4E-02	6E-02	8E-03	1E-01	2E-07	3E-07	3E-06	8E-08	3E-06	4E-04	5E-03	2E-03	7E-04	8E-03

Notes  
Shaded cells indicate noncancer HI >1, cancer risk >1E-04, or TEQ<sub>DF</sub> cancer HI >1.  
FCA = fish collection area  
HI = hazard index  
TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

Table 5-12  
Summary of Baseline Central Tendency Exposure Hazards and Risks for the Area North of I-10 and Aquatic Environment

Scenario	Noncancer HI					Cancer Risk					TEQ <sub>DF</sub> Cancer HI				
	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total	
Hypothetical Recreational Fisher															
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	3E-06	4E-04	3E-01	3E-01		1E-10	9E-09	6E-07	6E-07		3E-07	3E-05	4E-02	4E-02	
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3	3E-06	4E-04	4E-03	5E-03		1E-10	9E-09	2E-08	3E-08		3E-07	3E-05	7E-04	7E-04	
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3	3E-06	4E-04	2E-03	2E-03		1E-10	9E-09	1E-08	2E-08		3E-07	3E-05	9E-05	1E-04	
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	3E-05	4E-03	3E-01	3E-01		8E-10	7E-08	6E-07	7E-07		4E-06	4E-04	4E-02	4E-02	
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	3E-05	4E-03	1E-02	1E-02		8E-10	7E-08	2E-08	9E-08		4E-06	4E-04	2E-03	3E-03	
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3	3E-05	4E-03	2E-03	6E-03		8E-10	7E-08	1E-08	9E-08		4E-06	4E-04	9E-05	4E-04	
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	3E-03	3E-01	3E-01	6E-01		1E-09	2E-07	6E-07	7E-07		9E-04	8E-02	4E-02	1E-01	
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	3E-03	3E-01	1E-02	3E-01		1E-09	2E-07	2E-08	2E-07		9E-04	8E-02	2E-03	8E-02	
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	3E-03	3E-01	2E-03	3E-01		1E-09	2E-07	1E-08	2E-07		9E-04	8E-02	9E-05	8E-02	
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	2E-05	3E-03	3E-01	3E-01		1E-09	9E-08	7E-07	7E-07		1E-06	1E-04	3E-02	3E-02	
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3	2E-05	3E-03	4E-03	8E-03		1E-09	9E-08	2E-08	1E-07		1E-06	1E-04	7E-04	8E-04	
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1	2E-05	3E-03	3E-03	6E-03		1E-09	9E-08	1E-08	1E-07		1E-06	1E-04	4E-04	5E-04	
	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total
Hypothetical Recreational Visitor															
Scenario 1 - Direct exposure Beach Area A	6E-06	1E-04	9E-04	2E-04	1E-03	2E-10	2E-09	2E-08	3E-09	2E-08	6E-07	9E-06	5E-05	1E-05	7E-05
Scenario 2 - Direct exposure Beach Area B/C	5E-05	1E-04	8E-03	2E-04	8E-03	2E-09	2E-09	1E-07	3E-09	2E-07	8E-06	9E-06	7E-04	1E-05	7E-04
Scenario 3 - Direct exposure Beach Area E	6E-03	1E-04	6E-01	2E-04	6E-01	3E-09	2E-09	3E-07	3E-09	3E-07	2E-03	9E-06	2E-01	1E-05	2E-01
Scenario 4 - Direct exposure Beach Area D	5E-05	1E-04	7E-03	2E-04	7E-03	2E-09	2E-09	2E-07	3E-09	2E-07	3E-06	9E-06	2E-04	1E-05	3E-04

Notes  
FCA = fish collection area  
HI = hazard index  
TEQ<sub>DF</sub> = toxicity equivalent concentration for dioxins and furans

**Table 5-13**  
**Hazards and Risks for Hypothetical Recreational Fisher Scenarios**

Scenario	Noncancer HI		Cancer Risk		TEQ <sub>DF</sub> Cancer HI	
	RME	CTE	RME	CTE	RME	CTE
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA2/3	2E+00	3E-01	1E-05	6E-07	3E-01	4E-02
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3	4E-02	5E-03	6E-07	3E-08	6E-03	7E-04
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3	3E-02	2E-03	5E-07	2E-08	1E-03	1E-04
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA2/3	2E+00	3E-01	1E-05	7E-07	3E-01	4E-02
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	3E-01	1E-02	3E-06	9E-08	7E-02	3E-03
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA2/3	8E-02	6E-03	3E-06	9E-08	7E-03	4E-04
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA2/3	5E+01	6E-01	2E-05	7E-07	1E+01	1E-01
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	4E+01	3E-01	1E-05	2E-07	1E+01	8E-02
3C - Direct exposure Beach Area E; Ingestion of crab from FCA2/3	4E+01	3E-01	1E-05	2E-07	1E+01	8E-02
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	2E+00	3E-01	1E-05	7E-07	3E-01	3E-02
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3	8E-02	8E-03	3E-06	1E-07	8E-03	8E-04
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1	8E-02	6E-03	2E-06	1E-07	6E-03	5E-04

**Notes**

Shaded cells indicate noncancer HI >1, cancer risk >1E-04, or TEQ<sub>DF</sub> cancer HI >1.

CTE = central tendency exposure

FCA = fish collection area

HI = hazard index

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

Table 5-14

Endpoint-Specific Noncancer Hazard Indices for Hypothetical Recreational Fisher Scenarios<sup>a</sup>

Scenario	RME HI
<b>1A—Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+00
Immune (PCBs, inorganic mercury)	9E-01
Skin/Dermal (inorganic arsenic)	8E-03
Liver (BEHP)	1E-03
Kidney (organic arsenic, cadmium)	5E-02
GI (copper)	7E-03
General Toxicity (chromium, nickel, zinc)	1E-02
Total	2E+00
<b>2A—Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+00
Immune (PCBs, inorganic mercury)	9E-01
Skin/Dermal (inorganic arsenic)	2E-02
Liver (BEHP)	1E-03
Kidney (organic arsenic, cadmium)	5E-02
GI (copper)	1E-02
General Toxicity (chromium, nickel, zinc)	2E-02
Total	2E+00
<b>3A—Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	4E+01
Immune (PCBs, inorganic mercury)	2E+00
Skin/Dermal (inorganic arsenic)	2E-02
Liver (BEHP)	1E-03
Kidney (organic arsenic, cadmium)	5E-02
GI (copper)	1E-01
General Toxicity (chromium, nickel, zinc)	6E-02
Total	5E+01
<b>3B—Direct exposure Beach Area E; Ingestion of clam from FCA 2</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	4E+01
Immune (PCBs, inorganic mercury)	7E-01
Skin/Dermal (inorganic arsenic)	2E-02
Liver (BEHP)	3E-04
Kidney (organic arsenic, cadmium)	3E-03
GI (copper)	1E-01
General Toxicity (chromium, nickel, zinc)	5E-02
Total	4E+01

Table 5-14

Endpoint-Specific Noncancer Hazard Indices for Hypothetical Recreational Fisher Scenarios<sup>a</sup>

Scenario	RME HI
<b>3C–Direct exposure Beach Area E; Ingestion of crab from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	4E+01
Immune (PCBs, inorganic mercury)	7E-01
Skin/Dermal (inorganic arsenic)	1E-02
Liver (BEHP)	3E-04
Kidney (organic arsenic, cadmium)	3E-03
GI (copper)	1E-01
General Toxicity (chromium, nickel, zinc)	5E-02
Total	4E+01
<b>4A–Direct exposure Beach Area D; Ingestion of catfish from FCA 1</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+00
Immune (PCBs, inorganic mercury)	1E+00
Skin/Dermal (inorganic arsenic)	2E-02
Liver (BEHP)	1E-03
Kidney (organic arsenic, cadmium)	4E-02
GI (copper)	2E-02
General Toxicity (chromium, nickel, zinc)	3E-02
Total	2E+00

**Notes**

Shaded cells indicate noncancer HI >1

BEHP = bis(2-ethylhexyl)phthalate

FCA = fish collection area

HI = hazard index

PCB = polychlorinated biphenyl

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Endpoint-specific noncancer hazards are shown for scenarios where the cumulative total HI for all chemicals of potential concern for human health was greater than 1.

**Table 5-15**  
**Hazards and Risks for Hypothetical Subsistence Fisher Scenarios**

Scenario	Noncancer HI	Cancer Risk	TEQ <sub>DF</sub> Cancer HI
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	2E+01	1E-04	3E+00
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3	5E-01	5E-06	8E-02
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3	2E-01	3E-06	1E-02
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	2E+01	1E-04	3E+00
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	3E+00	1E-05	9E-01
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3	4E-01	9E-06	3E-02
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	1E+02	1E-04	4E+01
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	1E+02	3E-05	4E+01
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	1E+02	3E-05	4E+01
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	2E+01	1E-04	3E+00
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3	6E-01	1E-05	8E-02
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1	5E-01	9E-06	5.5E-02

**Notes**

Shaded cells indicate noncancer HI >1, cancer risk >1E-04, or TEQ<sub>DF</sub> cancer HI >1

FCA = fish collection area

HI = hazard index

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

**Table 5-16**  
**Endpoint-Specific Hazard Indices for Hypothetical Subsistence Fisher Scenarios<sup>a</sup>**

Scenario	RME HI
<b>1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+01
Immune (PCBs, inorganic mercury)	7E+00
Skin/Dermal (inorganic arsenic)	5E-02
Liver (BEHP)	8E-03
Kidney (organic arsenic, cadmium)	4E-01
GI (copper)	3E-02
General Toxicity (chromium, nickel, zinc)	1E-01
Total	2E+01
<b>2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+01
Immune (PCBs, inorganic mercury)	7E+00
Skin/Dermal (inorganic arsenic)	1E-01
Liver (BEHP)	8E-03
Kidney (organic arsenic, cadmium)	4E-01
GI (copper)	4E-02
General Toxicity (chromium, nickel, zinc)	1E-01
Total	2E+01
<b>2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	3E+00
Immune (PCBs, inorganic mercury)	3E-01
Skin/Dermal (inorganic arsenic)	6E-02
Liver (BEHP)	6E-04
Kidney (organic arsenic, cadmium)	3E-02
GI (copper)	4E-02
General Toxicity (chromium, nickel, zinc)	4E-02
Total	3E+00
<b>3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+02
Immune (PCBs, inorganic mercury)	9E+00
Skin/Dermal (inorganic arsenic)	8E-02
Liver (BEHP)	9E-03
Kidney (organic arsenic, cadmium)	4E-01
GI (copper)	3E-01
General Toxicity (chromium, nickel, zinc)	2E-01
Total	1E+02
<b>3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+02
Immune (PCBs, inorganic mercury)	2E+00
Skin/Dermal (inorganic arsenic)	4E-02
Liver (BEHP)	1E-03
Kidney (organic arsenic, cadmium)	3E-02
GI (copper)	3E-01
General Toxicity (chromium, nickel, zinc)	1E-01
Total	1E+02

**Table 5-16**  
**Endpoint-Specific Hazard Indices for Hypothetical Subsistence Fisher Scenarios<sup>a</sup>**

Scenario	RME HI
<b>3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+02
Immune (PCBs, inorganic mercury)	2E+00
Skin/Dermal (inorganic arsenic)	4E-02
Liver (BEHP)	1E-03
Kidney (organic arsenic, cadmium)	2E-02
GI (copper)	3E-01
General Toxicity (chromium, nickel, zinc)	2E-01
Total	1E+02
<b>4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> , methylmercury)	1E+01
Immune (PCBs, inorganic mercury)	8E+00
Skin/Dermal (inorganic arsenic)	9E-02
Liver (BEHP)	8E-03
Kidney (organic arsenic, cadmium)	3E-01
GI (copper)	6E-02
General Toxicity (chromium, nickel, zinc)	2E-01
Total	2E+01

**Notes**

Shaded cells indicate noncancer HI > 1

BEHP = bis(2-ethylhexyl)phthalate

HI = hazard index

PCB = polychlorinated biphenyl

FCA = fish collection area

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Endpoint-specific noncancer hazards are shown for scenarios where the cumulative total HI for all chemicals of potential concern for human health was greater than 1.

**Table 5-17**  
**Hazards and Risks for Hypothetical Recreational Visitor Scenarios**

	Noncancer HI		Cancer Risk		TEQ <sub>DF</sub> Cancer HI	
	RME	CTE	RME	CTE	RME	CTE
Scenario 1 - Direct exposure Beach Area A and Soil North of I-10	6E-02	1E-03	8E-07	2E-08	6E-03	7E-05
Scenario 2 - Direct exposure Beach Area B/C and Soil North of I-10	1E-01	8E-03	4E-06	2E-07	1E-02	7E-04
Scenario 3 - Direct exposure Beach Area E and Soil North of I-10	6E+01	6E-01	1E-05	3E-07	2E+01	2E-01
Scenario 4 - Direct exposure Beach Area D and Soil North of I-10	1E-01	7E-03	3E-06	2E-07	8E-03	3E-04

**Notes**

Shaded cells indicate noncancer HI >1, cancer risk >1E-04, or TEQ<sub>DF</sub> cancer HI >1.

CTE = central tendency exposure

HI = hazard index

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

**Table 5-18**  
**Endpoint-Specific Hazard Indices for Hypothetical Recreational Visitor**  
**Scenarios<sup>a</sup>**

Scenario	RME HI
<b>Scenario 3 - Direct Exposure Beach Area E</b>	
Reproductive/Developmental (TEQ <sub>DF</sub> )	6E+01
Immune (PCBs, inorganic mercury)	1E+00
Skin/Dermal (inorganic arsenic)	3E-02
Liver (BEHP)	4E-04
Kidney (cadmium)	2E-03
GI (copper)	1E-01
General Toxicity (chromium, nickel, zinc)	7E-02
Total	6E+01

**Notes**

Shaded cells indicate noncancer HI >1.

BEHP = bis(2-ethylhexyl)phthalate

HI = hazard index

PCB = polychlorinated biphenyl

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Endpoint-specific noncancer hazards are shown for scenarios where the cumulative total HI for all chemicals of potential concern for human health was greater than 1.

**Table 5-19**  
**Hypothetical Exposure Scenarios for Refined Analysis for the Area North of I-10 and Aquatic Environment**

Scenario	Endpoint Specific Noncancer HI > 1	Cancer Risk > 1E-4	TEQ <sub>OF</sub> Cancer HI > 1
<b>Hypothetical Recreational Fisher</b>			
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3			
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3			
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	X		X
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1			
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3			
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2			
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	X		X
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3			
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3			
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3			
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	X		X
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1			
<b>Hypothetical Subsistence Fisher</b>			
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	X		X
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	X		X
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	X		X
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	X		X
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3			
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	X		
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	X		X
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3			
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3			
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3			
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	X		X
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1			
<b>Hypothetical Recreational Visitor</b>			
Scenario 1 - Direct exposure Beach Area A and Soil North of I-10			
Scenario 2 - Direct exposure Beach Area B/C and Soil North of I-10			
Scenario 3 - Direct exposure Beach Area E and Soil North of I-10	X		X
Scenario 4 - Direct exposure Beach Area D and Soil North of I-10			

**Notes**

Shaded cells indicate endpoint-specific noncancer HI >1, cancer risk >1E-04, or TEQ<sub>OF</sub> cancer HI >1.

FCA = fish collection area

HI = hazard index

TEQ<sub>OF</sub> = toxicity equivalent for dioxins and furans

Table 5-21  
Summary of Central Tendency Exposure Hazards and Risks, Background

Scenario	Noncancer HI					Cancer Risk					TEQ <sub>DF</sub> Cancer HI				
	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total	
Hypothetical Recreational Fisher															
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA2/3	5.1E-06	7.2E-04	1.2E-01	1.2E-01		2.1E-10	1.9E-08	3.8E-07	4.0E-07		3.9E-07	3.5E-05	5.5E-03	5.5E-03	
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3	5.1E-06	7.2E-04	1.7E-03	2.4E-03		2.1E-10	1.9E-08	1.6E-08	3.5E-08		3.9E-07	3.5E-05	2.0E-04	2.3E-04	
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3	5.1E-06	7.2E-04	1.3E-03	2.0E-03		2.1E-10	1.9E-08	1.9E-08	3.8E-08		3.9E-07	3.5E-05	6.8E-05	1.0E-04	
	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total
Hypothetical Recreational Visitor															
Scenario 1 - Direct exposure Beach Area A	1.0E-05	6.4E-05	1.4E-03	1.4E-04	1.6E-03	4.1E-10	2.3E-09	3.7E-08	2.9E-09	4.3E-08	7.7E-07	6.0E-06	6.9E-05	7.7E-06	8.4E-05

Notes  
FCA = fish collection area  
HI = hazard index  
TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

Table 5-20  
Summary of Reasonable Maximum Exposure Hazards and Risks, Background

Scenario	Noncancer HI					Cancer Risk					TEQ <sub>DF</sub> Cancer HI				
	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total		Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Total	
Hypothetical Recreational Fisher															
A - Direct exposure to sediment; Ingestion of catfish	2E-03	1E-02	1E+00	1E+00		5E-08	9E-07	7E-06	8E-06		9E-05	5E-04	1E-01	1E-01	
B - Direct exposure to sediment; Ingestion of clam	2E-03	1E-02	1E-02	3E-02		5E-08	9E-07	2E-07	1E-06		9E-05	5E-04	2E-03	2E-03	
C - Direct exposure to sediment; Ingestion of crab	2E-03	1E-02	1E-02	3E-02		5E-08	9E-07	3E-07	1E-06		9E-05	5E-04	6E-04	1E-03	
Hypothetical Subsistence Fisher															
A - Direct exposure to sediment; Ingestion of catfish	5E-03	4E-02	1E+01	1E+01		1E-07	2E-06	7E-05	7E-05		2E-04	1E-03	1E+00	1E+00	
B - Direct exposure to sediment; Ingestion of clam	5E-03	4E-02	2E-01	2E-01		1E-07	2E-06	3E-06	6E-06		2E-04	1E-03	2E-02	2E-02	
C - Direct exposure to sediment; Ingestion of crab	5E-03	4E-02	1E-01	2E-01		1E-07	2E-06	4E-06	7E-06		2E-04	1E-03	8E-03	1E-02	
	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Total
Hypothetical Recreational Visitor															
Direct exposure to sediment and soil	2E-03	1E-02	2E-02	3E-03	4E-02	7E-08	3E-07	1E-06	8E-08	2E-06	1E-04	2E-03	7E-04	2E-04	3E-03

Notes  
Shaded cells indicate noncancer HI >1, cancer risk >1E-04, or TEQ<sub>DF</sub> cancer HQ >1.  
HI = hazard index  
TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

**Table 5-22**  
**Probabilistic Results for Noncancer Hazards, Area North of I-10 and Aquatic Environment**

	Endpoint Category	Deterministic Results		Probabilistic Results		
		Recreational RME	Subsistence RME	50th Percentile	90th Percentile	95th Percentile
Baseline Hazards						
Hypothetical Fisher Scenario						
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	HI, immunotoxicity	9E-01	7E+00	4E-01	2E+00	3E+00
	HI, reproductive/developmental	1E+00	1E+01	5E-01	2E+00	3E+00
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	HI, immunotoxicity	9E-01	7E+00	4E-01	2E+00	3E+00
	HI, reproductive/developmental	1E+00	1E+01	5E-01	2E+00	3E+00
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	HI, immunotoxicity	2E+00	9E+00	4E-01	2E+00	3E+00
	HI, reproductive/developmental	4E+01	1E+02	1E+00	8E+00	1E+01
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	HI, immunotoxicity	1E+00	8E+00	4E-01	2E+00	3E+00
	HI, reproductive/developmental	1E+00	1E+01	6E-01	2E+00	4E+00
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	HI, immunotoxicity	2E-02	3E-01	0E+00	0E+00	7E-02
	HI, reproductive/developmental	2E-01	3E+00	4E-03	3E-02	3E-01
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	HI, immunotoxicity	7E-01	2E+00	0E+00	0E+00	7E-02
	HI, reproductive/developmental	4E+01	1E+02	5E-01	6E+00	1E+01
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	HI, immunotoxicity	7E-01	2E+00	0E+00	0E+00	1E-02
	HI, reproductive/developmental	4E+01	1E+02	4E-01	6E+00	1E+01
Hypothetical Visitor Scenario						
3 - Direct exposure Beach Area E and Soils North of I-10	HI, reproductive/developmental	6E+01		2E-01	2E+00	4E+00
Background Hazards						
Hypothetical Fisher Scenario						
A - Direct exposure background sediments; Ingestion of background catfish	HI, immunotoxicity	5E-01	4E+00	2E-01	1E+00	2E+00
	HI, reproductive/developmental	7E-01	6E+00	2E-01	1E+00	2E+00
B - Direct exposure background sediments; Ingestion of background clam	HI, immunotoxicity	5E-03	6E-02	0E+00	0E+00	3E-02
	HI, reproductive/developmental	8E-03	8E-02	3E-04	3E-03	3E-02
C - Direct exposure background sediments; Ingestion of background crab	HI, immunotoxicity	4E-04	6E-03	0E+00	0E+00	3E-03
	HI, reproductive/developmental	6E-03	6E-02	3E-04	3E-03	2E-02
Hypothetical Visitor Scenario						
Direct exposure background sediments and soils	HI, reproductive/developmental	9E-03		2E-04	9E-04	1E-03

**Notes**

Shaded cells indicate noncancer HI >1  
FCA = fish collection area  
HI = hazard index  
PRA = probabilistic risk assessment  
RME = reasonable maximum exposure

**Table 5-23**  
**Probabilistic Results for TEQ<sub>DF</sub> Cancer Hazards, Area North of I-10 and Aquatic Environment**

	Deterministic Results		Probabilistic Results		
	Recreational RME	Subsistence RME	50th Percentile	90th Percentile	95th Percentile
Baseline Hazards					
Hypothetical Fisher Scenario					
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	3E-01	3E+00	1E-01	5E-01	8E-01
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	3E-01	3E+00	1E-01	5E-01	8E-01
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	1E+01	4E+01	4E-01	2E+00	4E+00
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	3E-01	3E+00	1E-01	5E-01	7E-01
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	7E-02	9E-01	1E-03	1E-02	1E-01
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	1E+01	4E+01	1E-01	2E+00	3E+00
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	1E+01	4E+01	1E-01	2E+00	3E+00
Hypothetical Visitor Scenario					
3 - Direct exposure Beach Area E and Soils North of I-10	2E+01		5E-02	7E-01	1E+00
Background Hazards					
Hypothetical Fisher Scenario					
Fisher A - Direct exposure background sediments; Ingestion of background catfish	1E-01	1E+00	1E-02	1E-01	2E-01
Fisher B - Direct exposure background sediments; Ingestion of background clam	2E-03	2E-02	1E-04	9E-04	9E-03
Fisher C - Direct exposure background sediments; Ingestion of background crab	1E-03	1E-02	1E-04	9E-04	5E-03
Hypothetical Visitor Scenario					
Visitor - Direct exposure background sediments and soils	3E-03		7E-05	3E-04	4E-04

**Notes:**

Shaded cells indicate TEQ<sub>DF</sub> cancer HI >1

FCA = fish collection area

PRA = probabilistic risk assessment

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

**Table 5-24**  
**Comparison of Risk-Based Doses and Threshold Doses for the Cancer Endpoint**

<b>Tier 3 Source</b>	<b>Year Developed</b>	<b>Reported Dose Metric</b>	<b>Target Risk Level Used to Derive a Risk-specific Dose</b>	<b>Cancer Slope Factor (mg/kg-day)<sup>-1</sup></b>	<b>Calculated Risk-Specific Dose<sup>a</sup> (pg/kg-day)</b>	<b>Reported Threshold Dose (pg/kg-day)</b>
U.S. Environmental Protection Agency	1985	CSF	1.00E-04	156,000	0.64	--
California Environmental Protection Agency	1986	CSF	1.00E-04	130,000	0.77	--
World Health Organization	1991	TDI	--	--	--	10
Keenan et al.	1991	CSF	1.00E-04	9,000	11	--
U.S. Environmental Protection Agency	1997	CSF	1.00E-04	150,000	0.67	--
World Health Organization - low end of range	1998	TDI	--	--	--	1
World Health Organization - high end of range	1998	TDI	--	--	--	4
Agency for Toxic Substances and Disease Registry	1998	MRL	--	--	--	1
Joint Expert Committee on Food Additives	2002	TDI <sup>b</sup>	--	--	--	2.3
Ontario Ministry of the Environment	2005	TDI	--	--	--	10
U.S. Food and Drug Administration - high	2003	CSF	1.00E-04	30,000	3.3	--
U.S. Food and Drug Administration - low	2003	CSF	1.00E-04	9,700	10	--
Simon et al.	2009	CSF	1.00E-04	100,000	1.0	1
Simon et al.	2009	TDI	--	--	--	100

**Notes:**

-- = not applicable. Target risk, cancer slope factor, and risk-specific dose not applicable when TCDD is evaluated as a threshold carcinogen; Threshold dose not applicable when TCDD is considered a non-threshold carcinogen.

CSF = cancer slope factor

MRL = minimal risk level

TCDD = tetrachlorinated dibenzo dioxins

TDI = tolerable daily intake

a - Risk-specific doses were calculated using a target risk level of 1E-04 as follows: Risk-specific Dose = Target Risk Level/Cancer Slope Factor.

b - Joint Expert Committee on Food Additives value is a provisional tolerable monthly intake value; TDI derived by dividing by 30 to develop a tolerable daily intake.

Table S-25

Comparison of Approaches for Estimating PCB and Dioxin and Furan Hazards and Risks for Scenario 1A

Metric Evaluated for Dioxins, Furans, and PCBs	Toxicological Criteria Used for the Cancer and Noncancer Endpoints	Cancer Hazard		Cancer Risk		Noncancer Hazard	
		Cancer Hazard	Percent Contribution to Total Cancer Hazard	Cancer Risk	Percent Contribution to Total Cancer Risk	Noncancer Hazard	Percent Contribution to Total Noncancer Hazard
TEQ <sub>DF</sub>	TDI of 2.3 pg/kg-day for cancer; RfD of 0.7 pg/kg-day for noncancer	0.33	72	--	--	1.1	72
TEQ <sub>P</sub>		0.13	28	--	--	0.42	28
TEQ <sub>DFP</sub>		0.46	100	--	--	1.52	100
TEQ <sub>DF</sub>	CSF of 150,000 (mg/kg-day) <sup>-1</sup> ; RfD of 0.7 pg/kg-day for noncancer	--	--	2.6E-05	72	1.1	72
TEQ <sub>P</sub>		--	--	9.9E-06	28	0.42	28
TEQ <sub>DFP</sub>		--	--	3.6E-05	100	1.52	100
TEQ <sub>DF</sub>	CSF of 150,000 (mg/kg-day) <sup>-1</sup> ; RfD of 0.7 pg/kg-day for noncancer	--	--	2.6E-05	77	1.1	56
Total PCBs (sum of 43 congeners)	CSF of 2 (mg/kg-day) <sup>-1</sup> ; RfD of 2E-05 mg/kg-day for noncancer	--	--	7.9E-06	23	0.88	44
Total Risk		--	--	3.4E-05		1.98	100
TEQ <sub>DF</sub>	CSF of 9,000 (mg/kg-day) <sup>-1</sup> ; RfD of 0.7 pg/kg-day for noncancer	--	--	1.6E-06	16	1.1	56
Total PCBs (sum of 43 congeners)		--	--	7.9E-06	84	0.88	44
Total Risk		--	--	9.5E-06	100	1.98	100
TEQ <sub>DF</sub>	CSF of 1,000,000 (mg/kg-day) <sup>-1</sup> ; RfD of 0.7 pg/kg-day for noncancer	--	--	1.7E-04	96	1.1	56
Total PCBs (sum of 43 congeners)		--	--	7.9E-06	4	0.88	44
Total Risk		--	--	1.8E-04	100	1.98	100

## Notes:

-- = not applicable. Cancer hazard is not applicable when TCDD is evaluated as a threshold carcinogen using a CSF; Cancer risk is not applicable when TCDD is considered a non-threshold carcinogen and evaluated using a TDI.

CSF = cancer slope factor

PCB = polychlorinated biphenyl

TCDD = tetrachlorinated dibenzo dioxins

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>DFP</sub> = sum of TEQ<sub>DF</sub> and TEQ<sub>P</sub>

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

TDI = tolerable daily intake

RfD = reference dose

RME = reasonable maximum exposure

**Table 6-1**

**Exposure Point Concentrations for Soils in the Area of Investigation on the Peninsula South of I-10**

<b>COPC<sub>H</sub></b>	<b>Surface soils (0-6 inches)</b>		<b>Surface and shallow subsurface soils (0-12 inches)</b>	
	<b>RME (mg/kg) <sup>a</sup></b>	<b>CTE (mg/kg) <sup>a</sup></b>	<b>RME (mg/kg) <sup>a</sup></b>	<b>CTE (mg/kg) <sup>a</sup></b>
<b>Dioxins and Furans</b>				
TEQ <sub>DF</sub> (ND=1/2DL)	2.79E-05	1.03E-05	2.46E-05	1.07E-05
TEQ <sub>DF</sub> (ND= DLO)	2.82E-05	1.0E-05	2.47E-05	1.05E-05
<b>Metals</b>				
Arsenic	110	31	97	30
<b>Semivolatile Organic Compounds</b>				
Benzo(a)pyrene	0.368	0.140	0.345	0.116

**Notes**

COPC<sub>H</sub> = chemical of potential concern for human health

CTE = central tendency exposure

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = nondetects set at zero

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - CTE exposure point concentrations are mean values and RME exposure point concentrations are the lower of upper confidence limit and maximum values (see Appendix E).

Table 6-2

Exposure Parameters for Deterministic Evaluations, Area of Investigation on the Peninsula South of I-10<sup>a</sup>

		Units	Hypothetical Trespasser		Hypothetical Commercial Worker	
			RME	CTE	RME	CTE
All Pathways						
Body weight	BW	kg	74	74	80	80
Exposure duration	ED	years	7	4	25	12
Fraction of total daily soil intake that is site-related	FI <sub>soil</sub>	% as fraction	0.5	0.25	1	1
Exposure frequency, soil	EF <sub>soil</sub>	days/year	24	12	225	225
Averaging time - non-carcinogens	AT <sub>n</sub>	days	2,555	1,460	9,125	4,380
Averaging time - carcinogens	AT <sub>c</sub>	days	28,470	28,470	28,470	28,470
Ingestion of Soil						
Ingestion rate, soil	IR <sub>soil</sub>	mg/day	41	41	100	50
Dermal Contact with Soil						
Skin surface area	SA	cm <sup>2</sup>	5,550	5,550	3,470	3,470
Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	0.2	0.2
Event frequency	EV	1/day	1	1	1	1

**Notes**

CTE = central tendency exposure

RME = reasonable maximum exposure

a - Chemical-specific parameters, including relative bioavailability, and dermal absorption factors are shown in Table 5-7.

**Table 6-3**  
**Summary of Baseline Hazards and Risks for the Area of Investigation on the Peninsula South of I-10**

	Noncancer HI		Cancer Risk		TEQ <sub>DF</sub> Cancer HI	
	RME	CTE	RME	CTE	RME	CTE
Hypothetical Trespasser - Direct exposure to Soils	6E-03	4E-04	2E-07	9E-09	2E-04	2E-05
Hypothetical Commercial Worker - Direct exposure to Soils	2E-01	4E-02	3E-05	3E-06	6E-03	2E-03

**Notes**

CTE = central tendency exposure

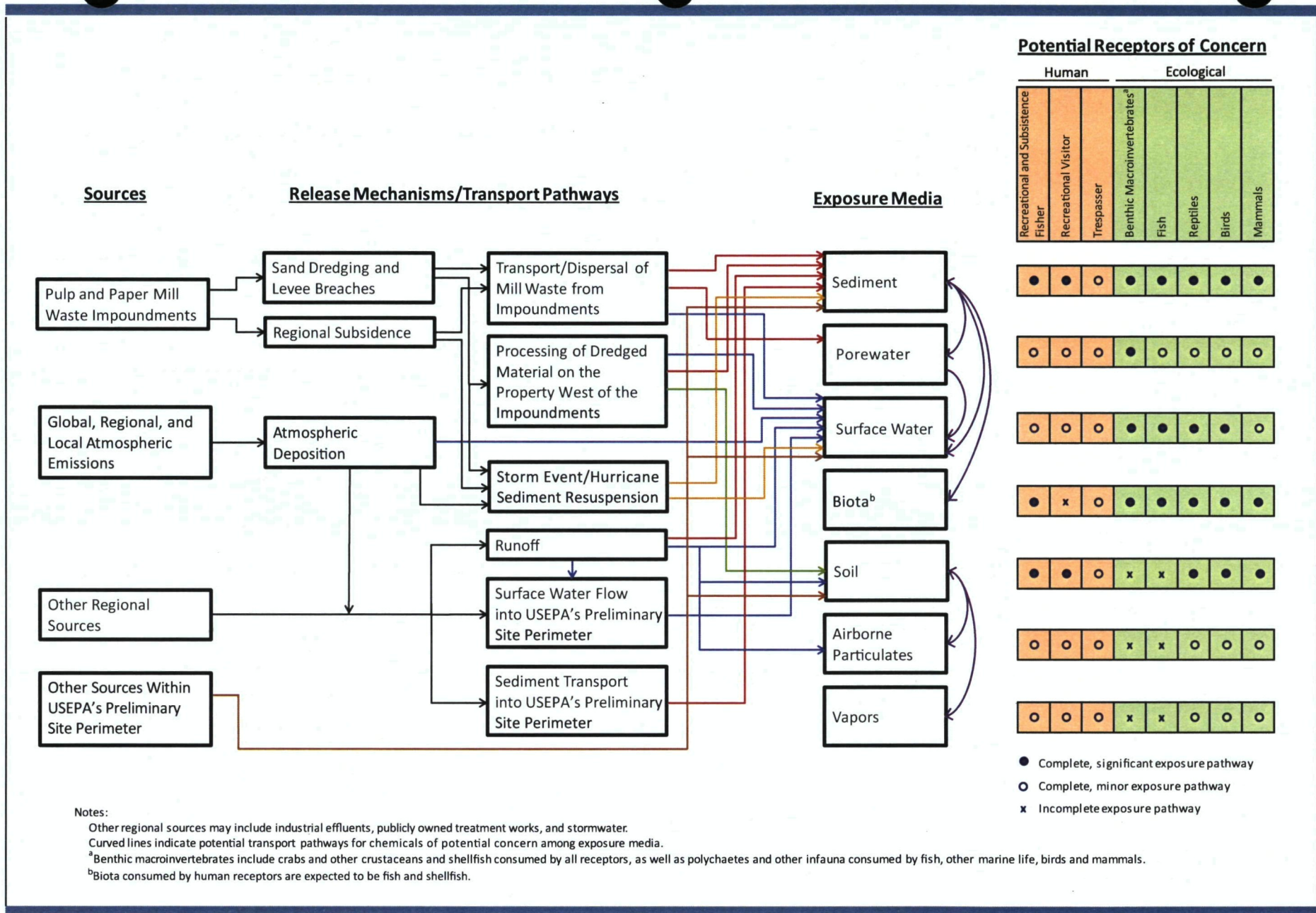
HI = hazard index

RME = reasonable maximum exposure

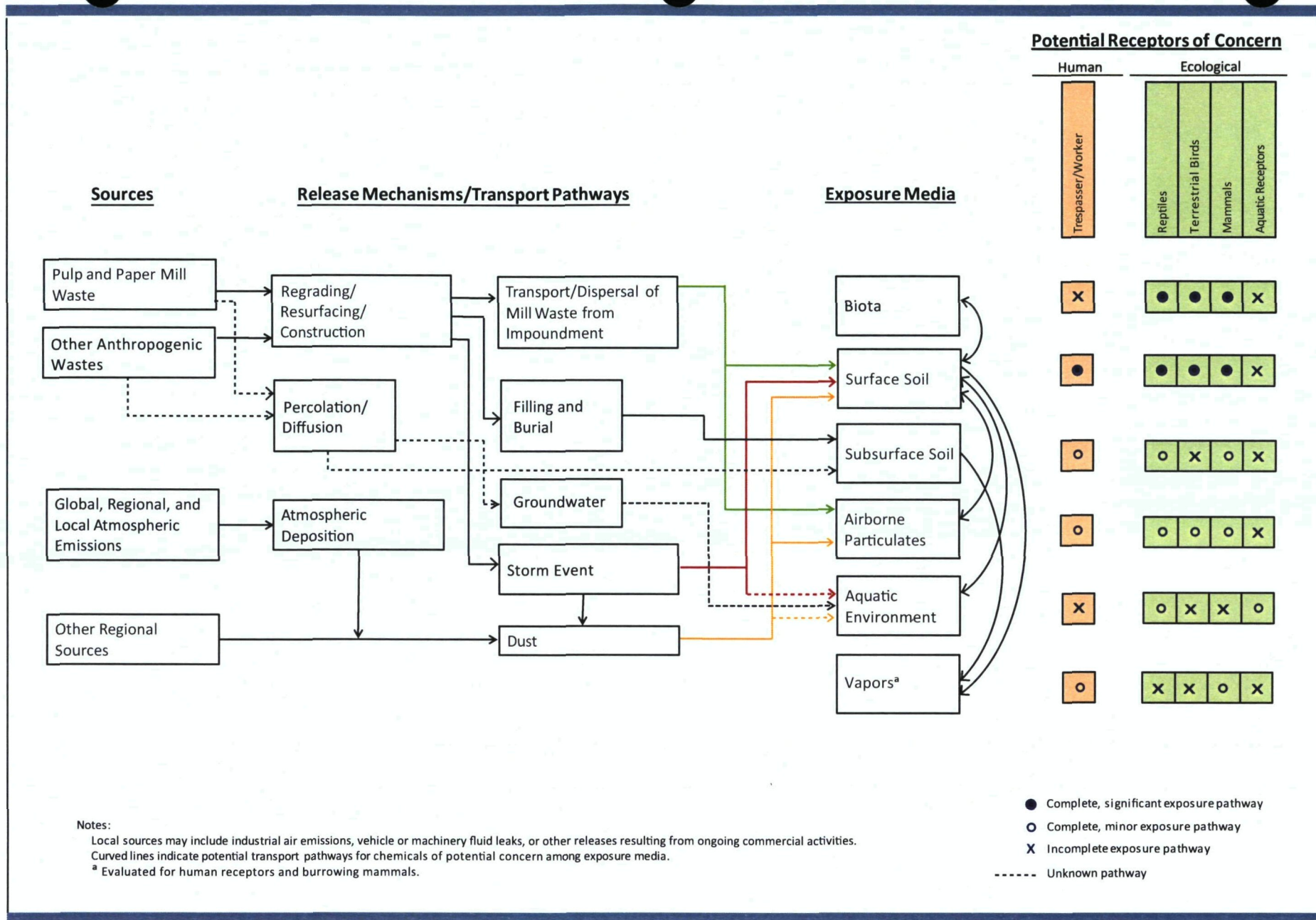
TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

## FIGURES

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**Figure 1-1**  
 Conceptual Site Model Pathways for the Area  
 North of I-10 and Aquatic Environment  
 Draft Baseline Human Health Risk Assessment  
 San Jacinto River Waste Pits Superfund Site



P:\Projects\643 SJWaste IPC\Production MXDs\BHHRA\Figure 1-3 AreaOverview.mxd 11/28/2012 4:10:36 PM





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

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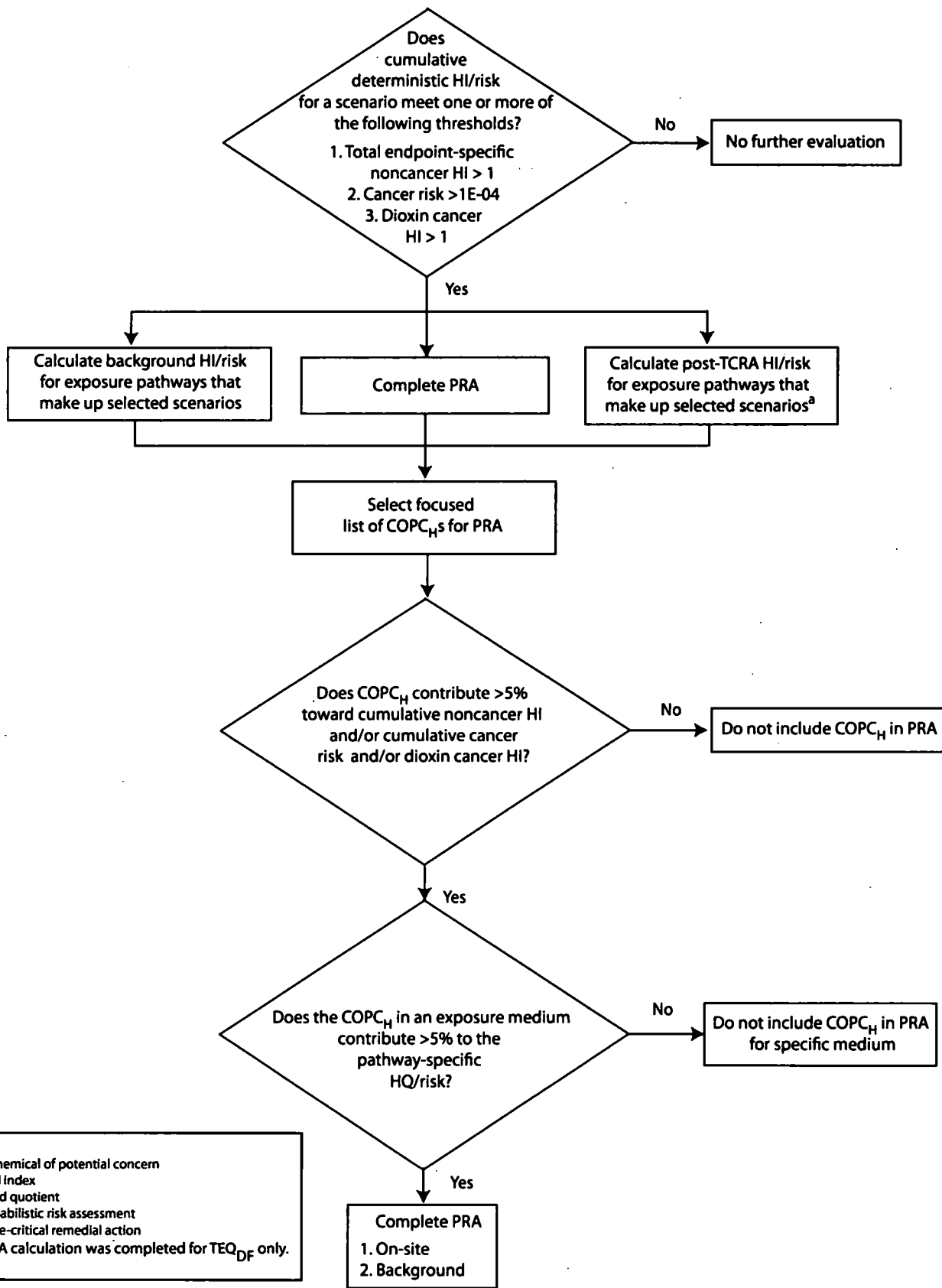
Scale in Feet

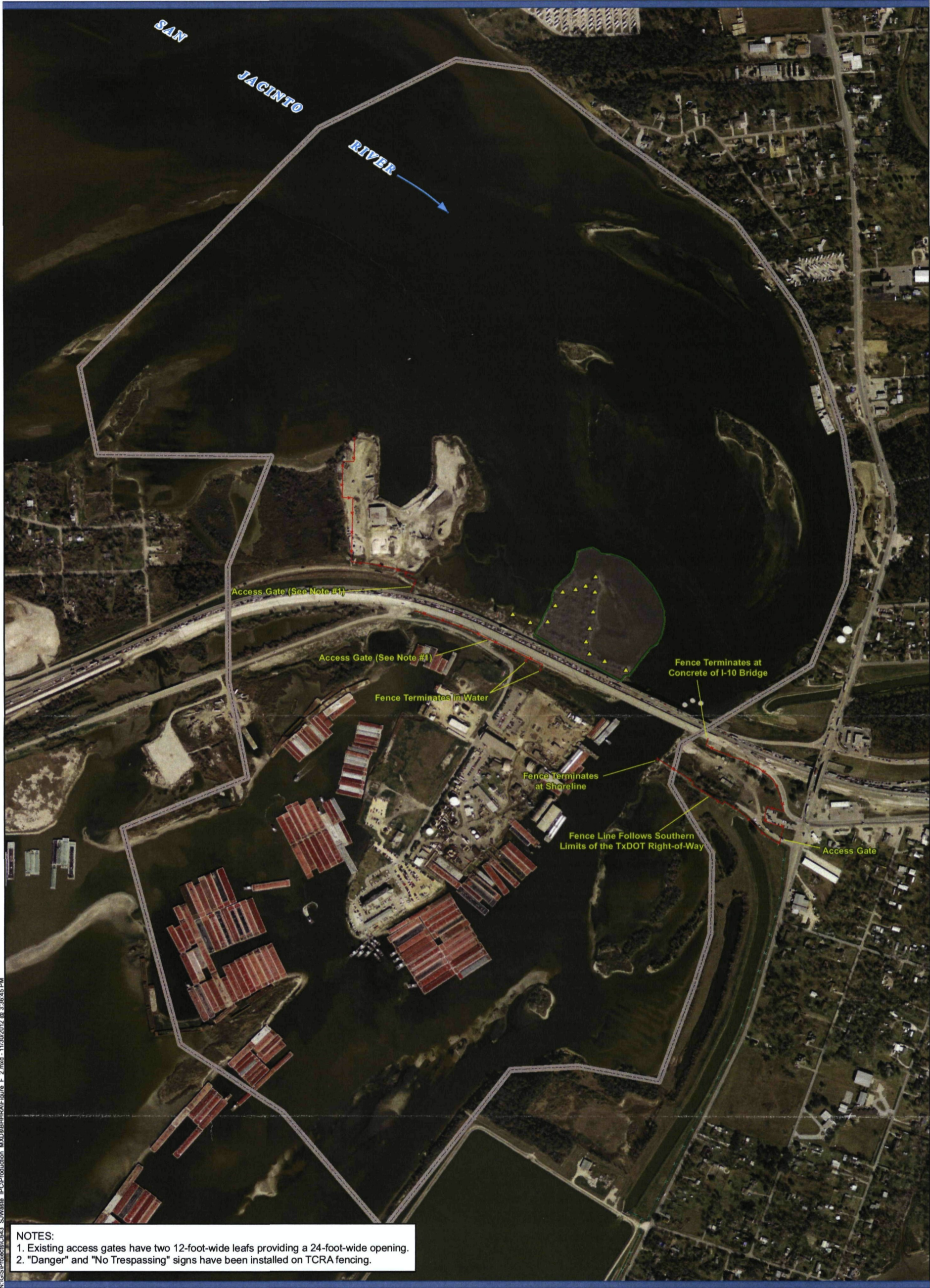
-  USEPA's Preliminary Site Perimeter
-  Original 1966 Perimeter of the Impoundments North of I-10
-  Approximate TCRA Footprint
-  Soil Investigation Area 4

\*Designation of the sand separation area is intended to be a general reference to areas in which such activities are believed to have taken place based on visual observations of aerial photography from 1998 through 2002.

FEATURE SOURCES:  
Aerial Imagery: 0.5-meter, Photo Date: 01/14/2009  
Texas Strategic Mapping Program (StratMap), TNRIIS

**Figure 1-3**  
Overview of Area within USEPA's Preliminary Site Perimeter  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site





**Figure 1-5**  
Fencing Introduced as Part of the Time-Critical Removal Action and by the Coastal Water Authority  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site

K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\09055701-RP-093.dwg Fig 1-2

Nov 16, 2012 10:26am tgriga



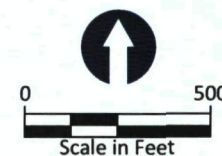
**SOURCE:** Google Map Pro 2009

**NOTE:** TCRA = Time Critical Removal Action

**LEGEND:**

— — — Original 1966 Perimeter of the Impoundments North of I-10

TRCA Footprint



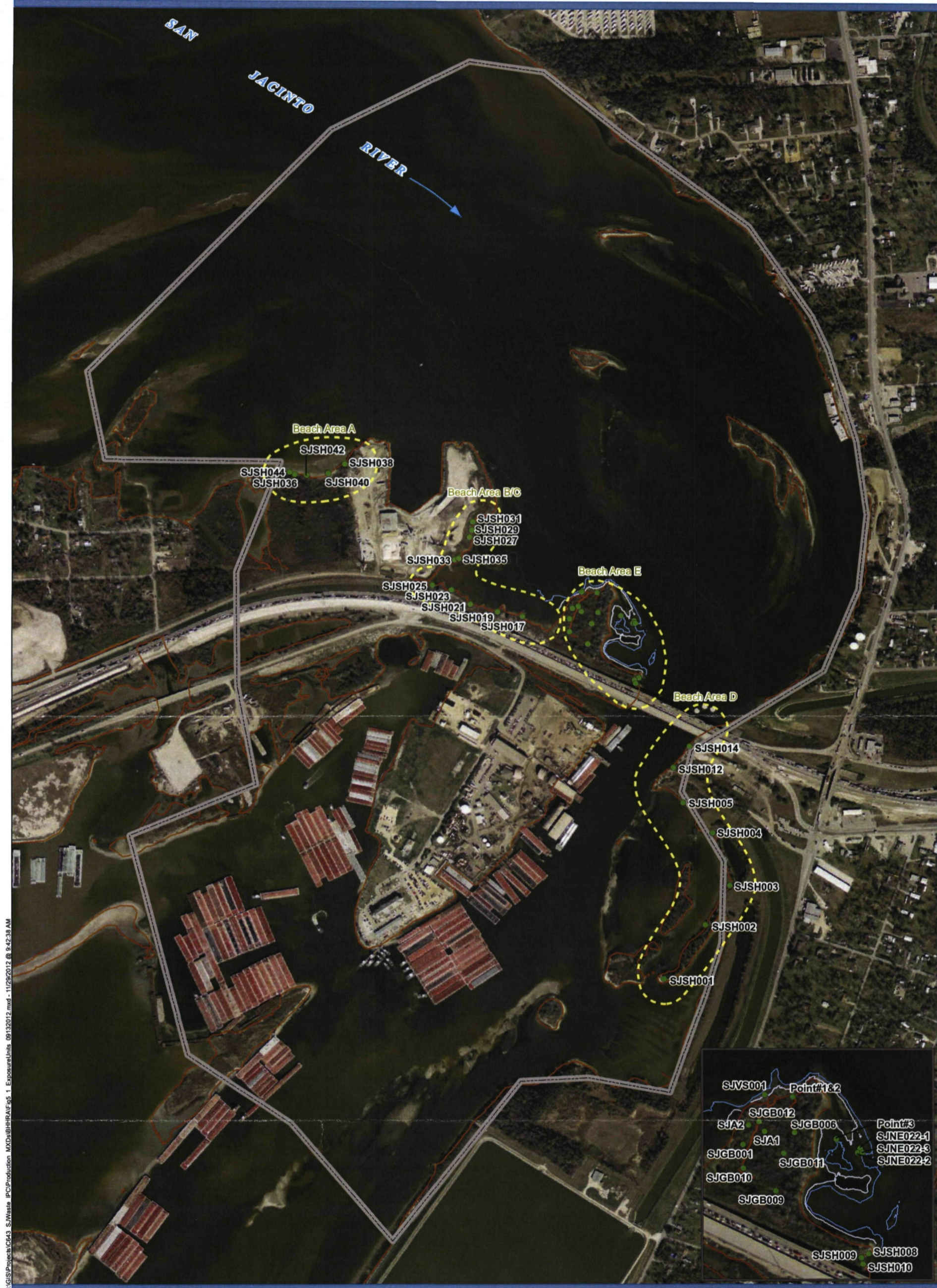
<u>Exposure Media</u>	<u>Exposure Route</u>	<u>Potential Human Receptors of Concern</u>		
		Recreational and Subsistence Fishers	Recreational Visitor	Trespasser
Sediment	Ingestion	●	●	○
	Dermal Contact	●	●	○
Porewater	Dermal Contact	○	○	○
Surface Water	Ingestion	○	○	○
	Dermal Contact	○	○	○
Fish and Shellfish	Ingestion	●	x	○
Soil	Ingestion	●	●	○
	Dermal Contact	●	●	○
Airborne Particulates	Inhalation	○	○	○
Vapors	Inhalation	○	○	○

- Potentially complete and significant exposure pathway
- Potentially complete but minor exposure pathway
- x Incomplete exposure pathway

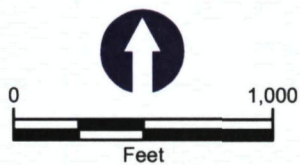
		Potential Human Receptors of Concern
<u>Exposure Media</u>	<u>Exposure Route</u>	Trespasser/Worker
Soil	Ingestion	●
	Dermal contact	●
Airborne Particulates and Vapors	Inhalation	○

Notes:

- Potentially complete and significant exposure pathway
- Potentially complete but minor exposure pathway



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- Surface Sediment Sample Location
- Exposure Unit Designation
- USEPA's Preliminary Site Perimeter
- 0 Contour (NAVD 88)<sup>a</sup>
- 2 (feet)<sup>b</sup>
- 1 (feet)<sup>b</sup>

Notes: <sup>a</sup> Tidal conditions under which this contour was measured are unknown.  
<sup>b</sup> Contours reflect pre-TCRA conditions.

**Figure 5-1**  
 Exposure Units for Sediment, Area North of I-10 and Aquatic Environment Baseline  
 Draft Baseline Human Health Risk Assessment  
 San Jacinto River Waste Pits Superfund Site



N:\GIS\Projects\CS43\_SJWaste\_IPC\Production\_MXD\BHHRA\Fig 5-2\_ExpUnitsTissue\_09132012.mxd - 11/28/2012 @ 9:45:26 AM

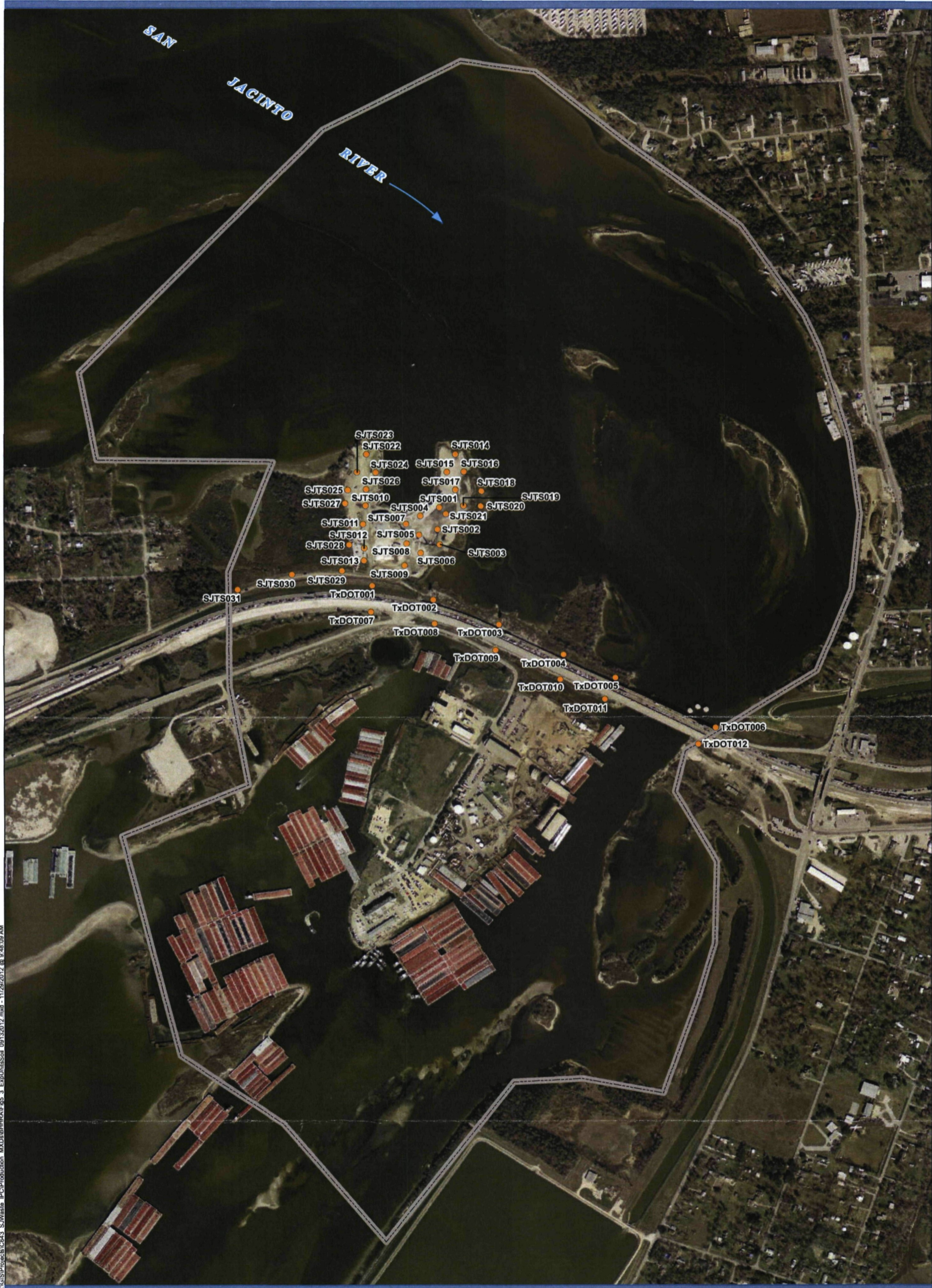
**ANCHOR**  
QEA

**integral**  
consulting inc.

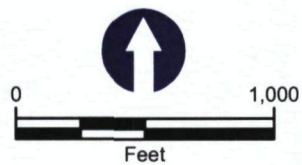
0 1,000  
Feet

- Large Fish Collection Location (University of Houston and Parsons, 2009)
- Large Fish and Blue Crab Fish Collection Area
- Hardhead Catfish Fillet and Blue Crab Exposure Unit: "FCA 1"
- Hardhead Catfish Fillet and Blue Crab Exposure Unit: "FCA 2/3"
- Clam Exposure Unit: "FCA 1/3"
- Clam Exposure Unit: "FCA 2"
- Original 1966 Perimeter of the Impoundments North of I-10
- USEPA's Preliminary Site Perimeter

**Figure 5-2**  
Exposure Units for Fish and Shellfish Tissue, Area North of I-10 and Aquatic Environment  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site



N:\GIS\Projects\IC043\_S.Waste\_IPC\Production\_MXD\BHRAT\Fig 3\_Exp\Units\Soil\_08132012.mxd - 11/29/2012 @ 9:48:09 AM



- Surface Soil Sample Location
- ▭ USEPA's Preliminary Site Perimeter

**Figure 5-3**  
Exposure Unit for Soils, Area North of I-10 and  
Aquatic Environment, Baseline  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site



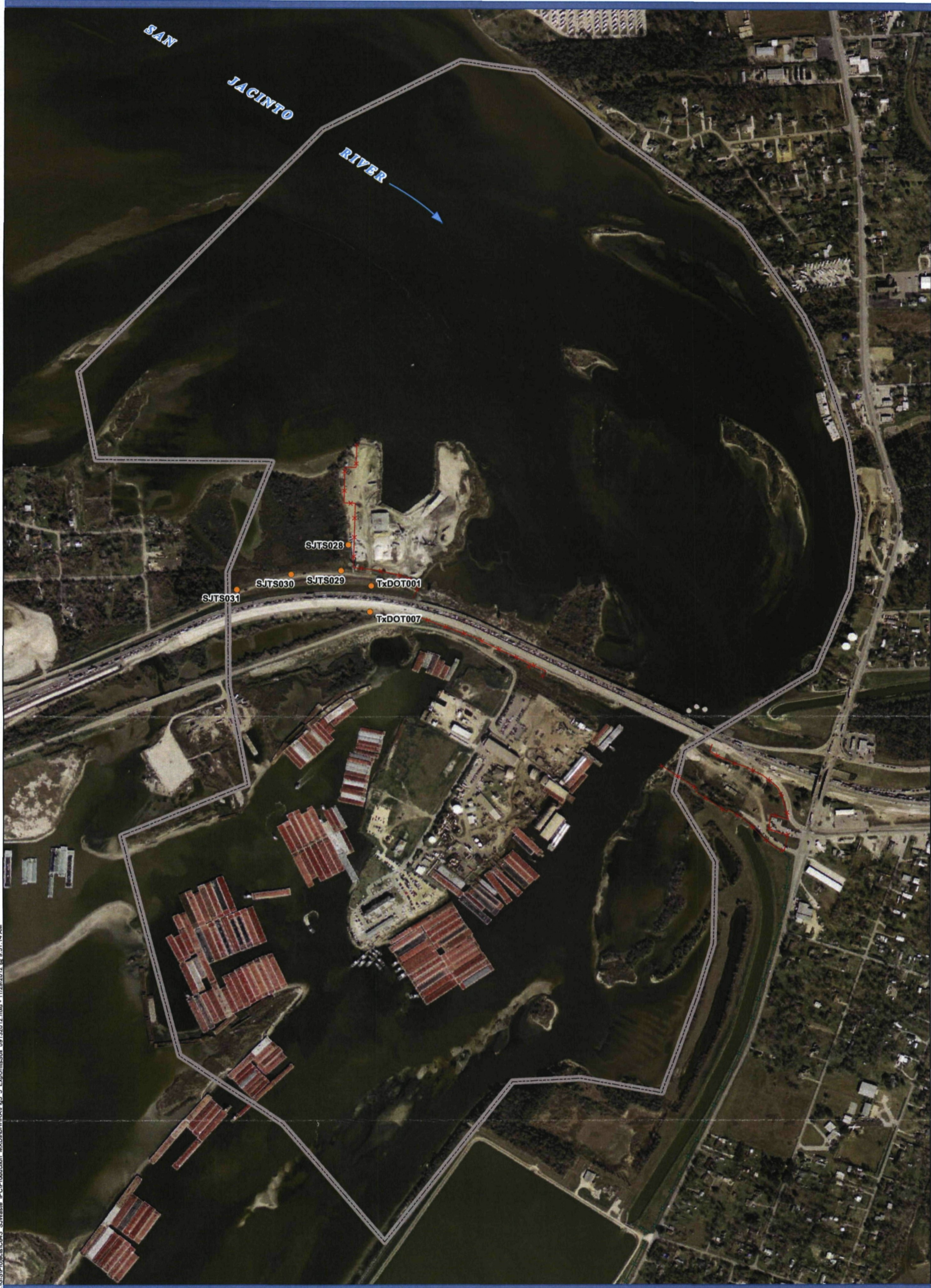
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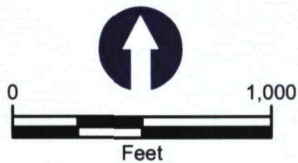
- Surface Sediment Sample Location
- Exposure Unit Designation
- TCRA Fence Line
- Coastal Water Authority Fence Line
- 0 Contour (NAVD 88)<sup>a</sup>
- USEPA's Preliminary Site Perimeter

Note: <sup>a</sup> Tidal conditions under which this contour was measured are unknown.

**Figure 5-4**  
Exposure Unit for Sediment, Area North of I-10 and Aquatic Environment, Post-TCRA Draft Baseline Human Health Risk Assessment San Jacinto River Waste Pits Superfund Site

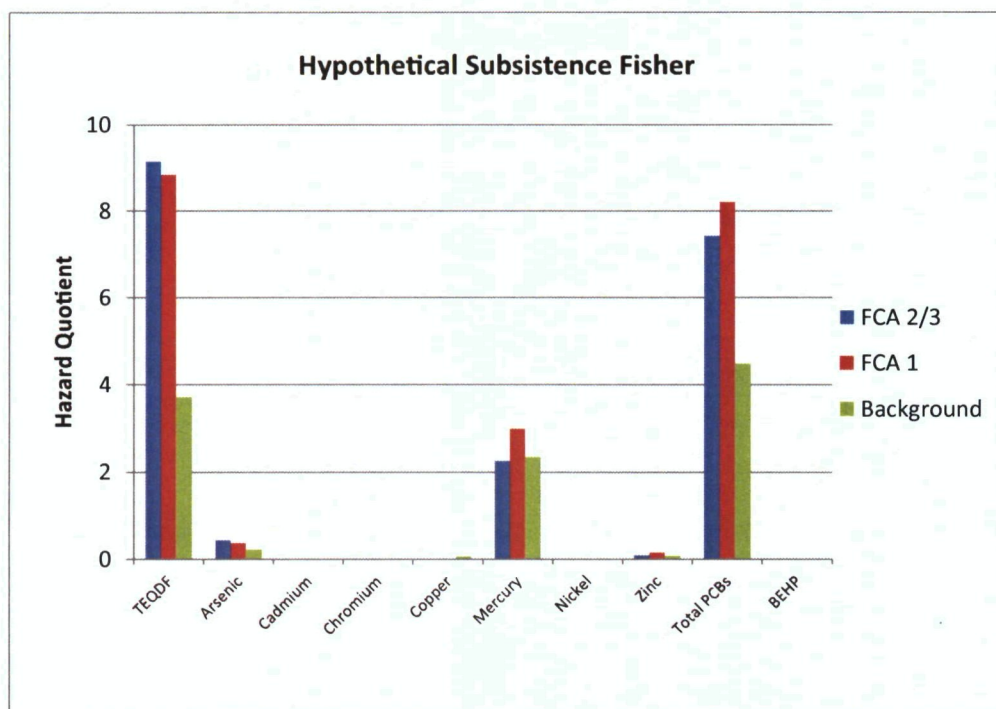
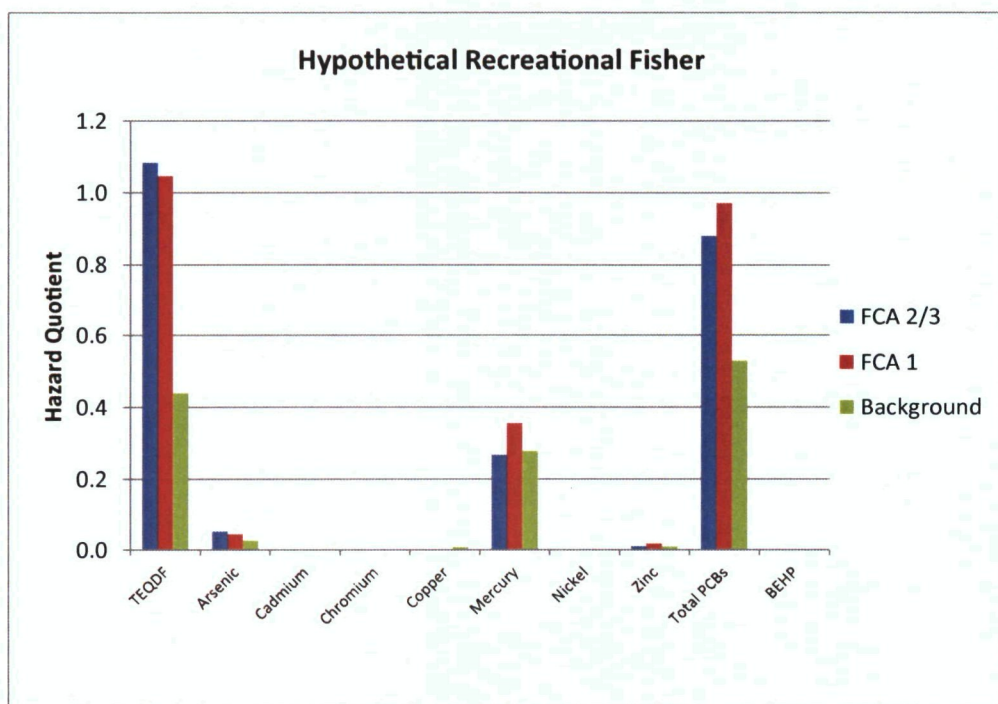


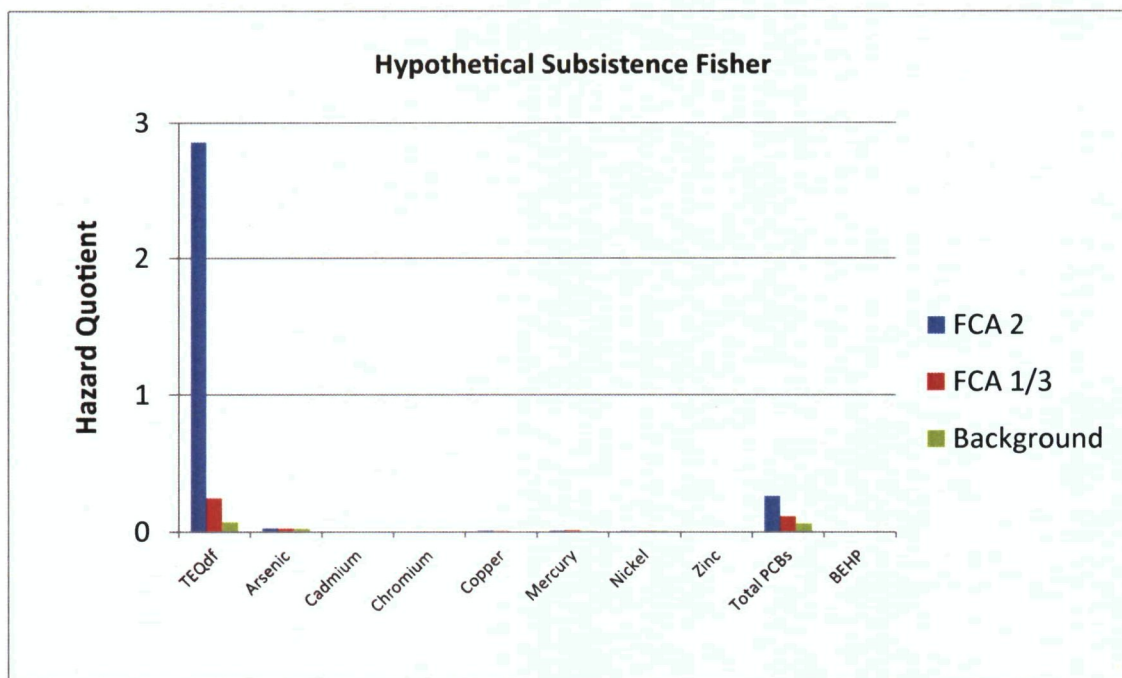
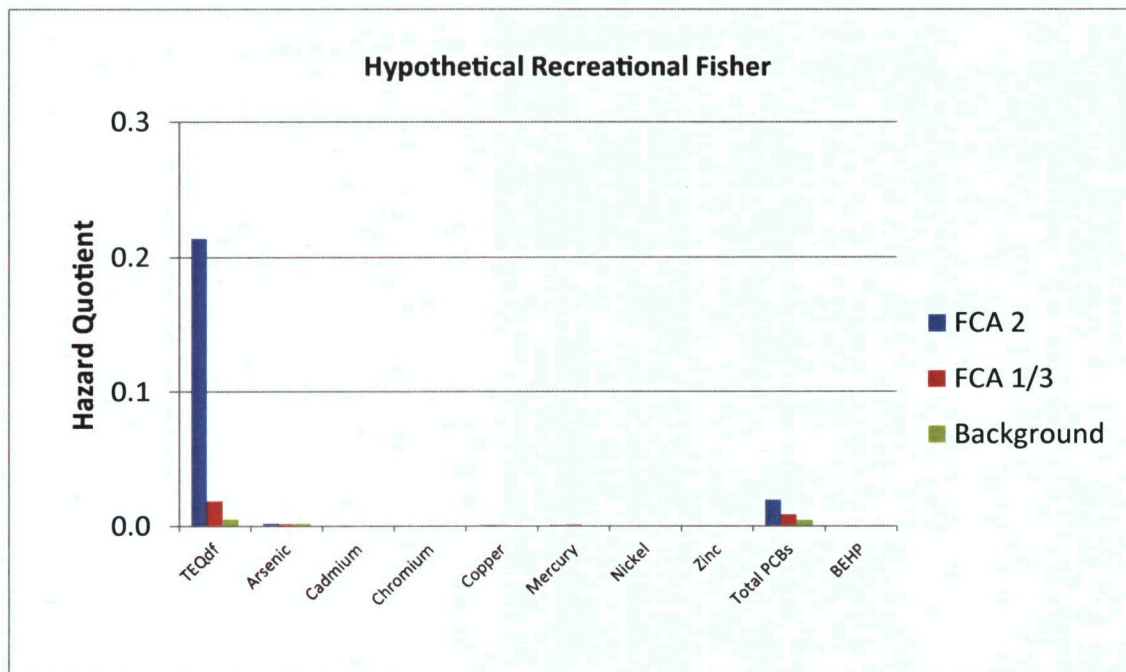
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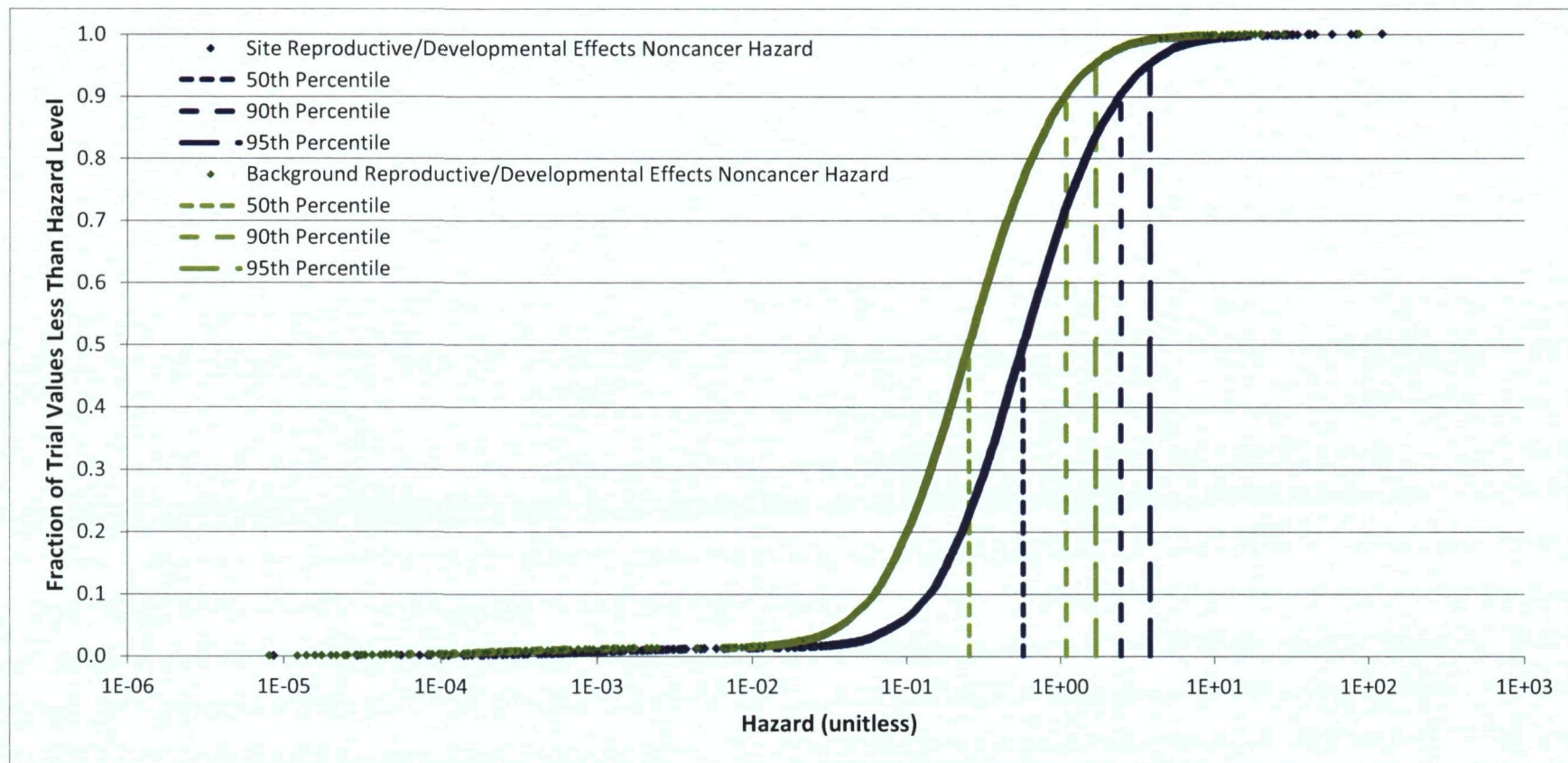


- Surface Soil Sample Location
- x— TCRA Fence Line
- x— Coastal Water Authority Fence Line
- USEPA's Preliminary Site Perimeter

**Figure 5-5**  
Exposure Unit for Soils, Area North of I-10 and  
Aquatic Environment, Post-TCRA  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site







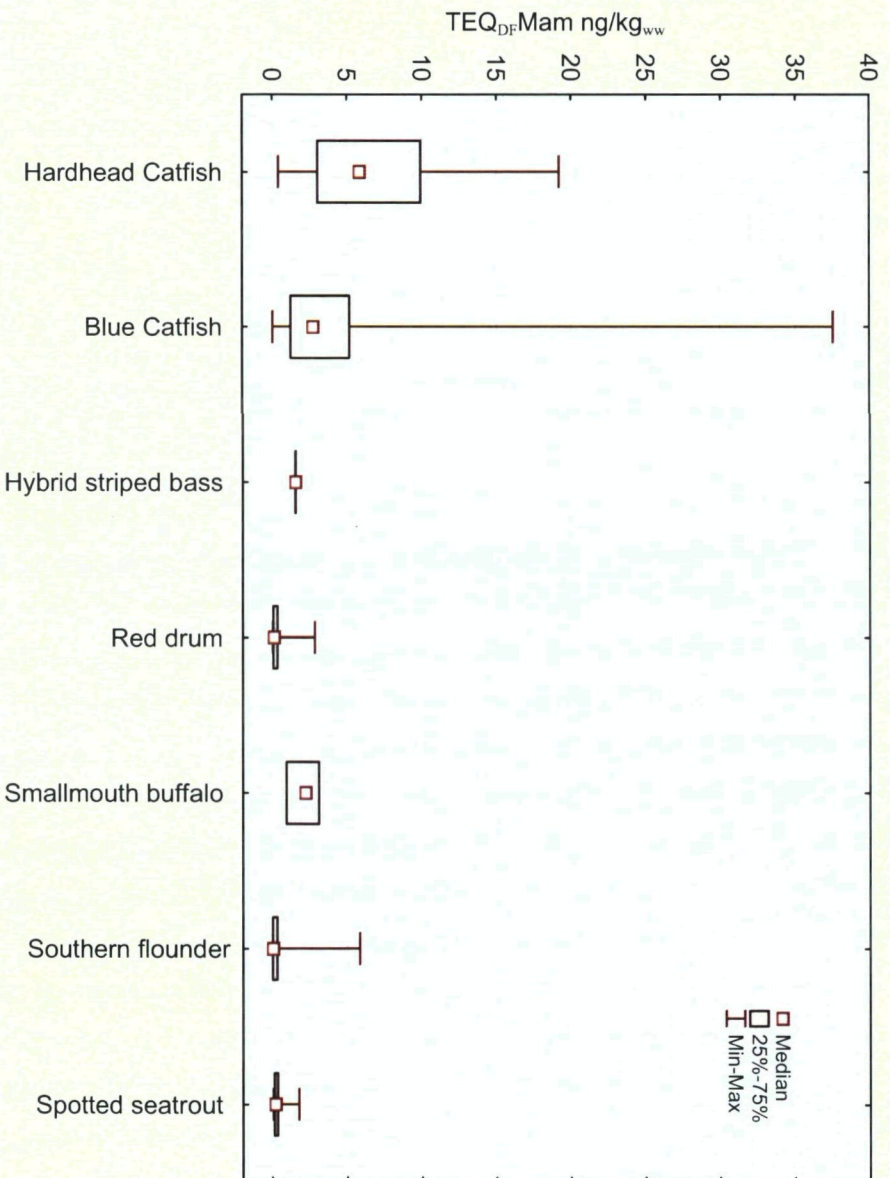
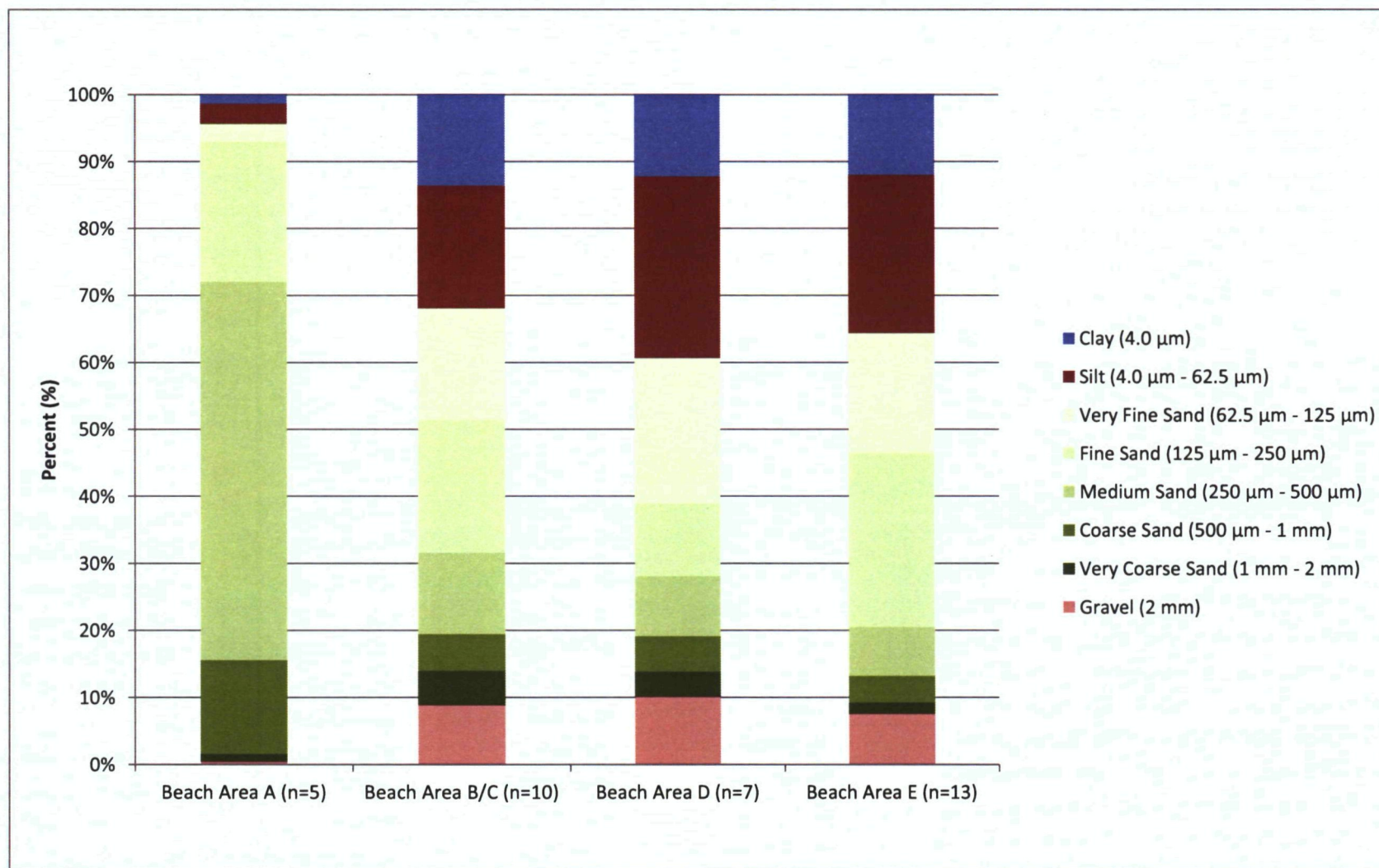
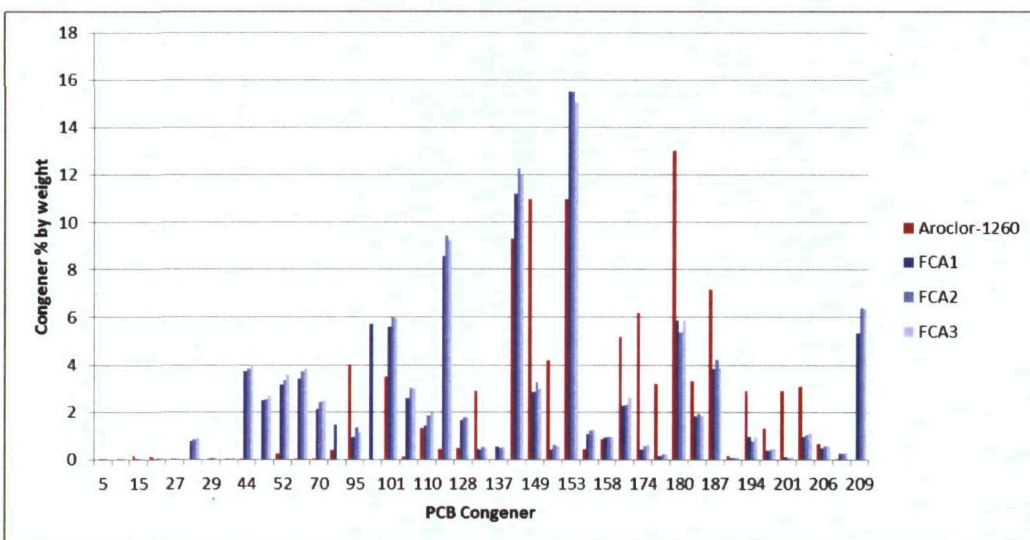
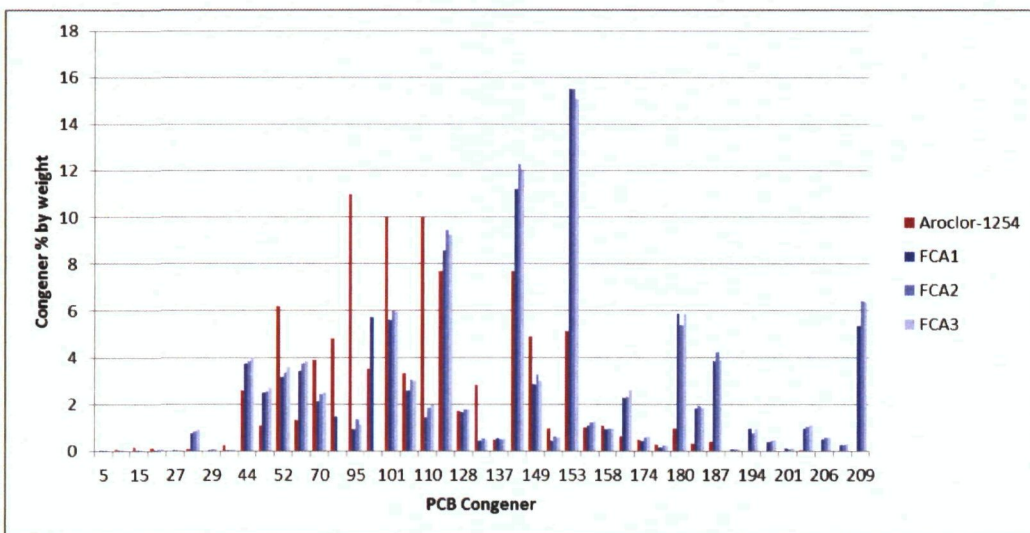
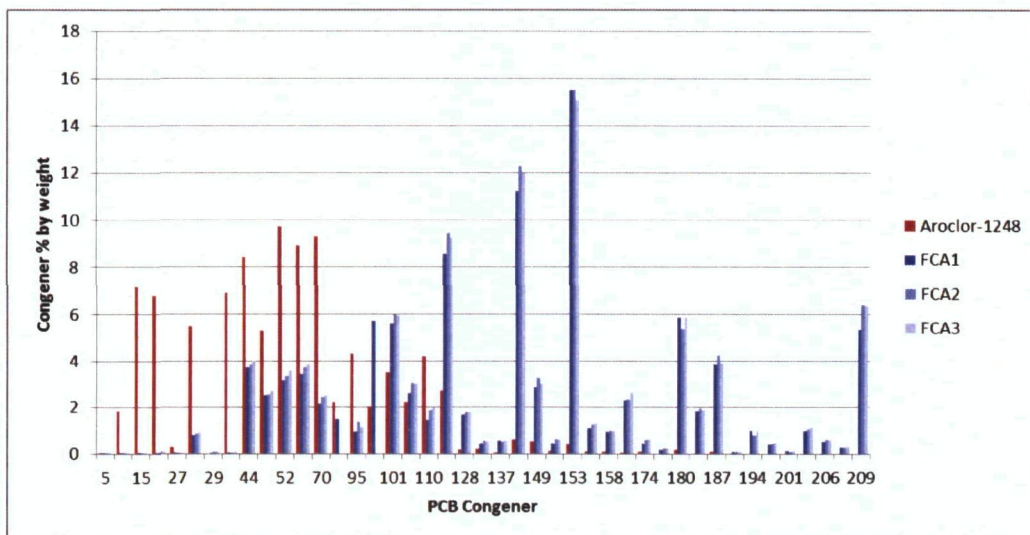
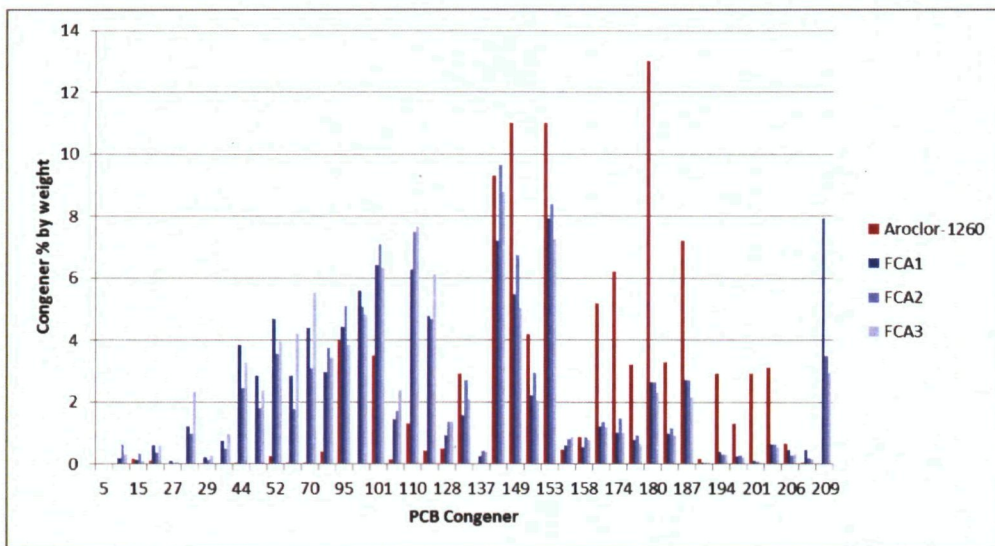
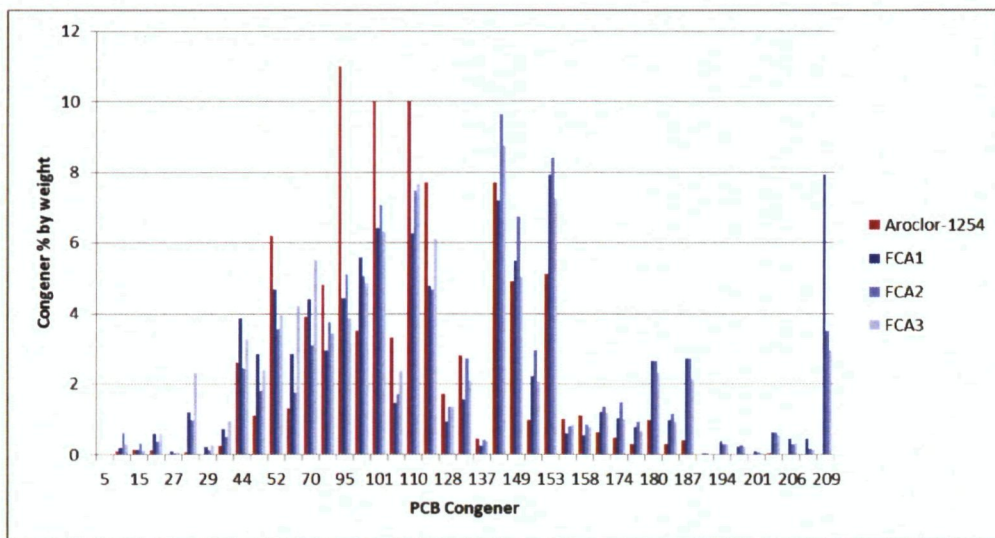
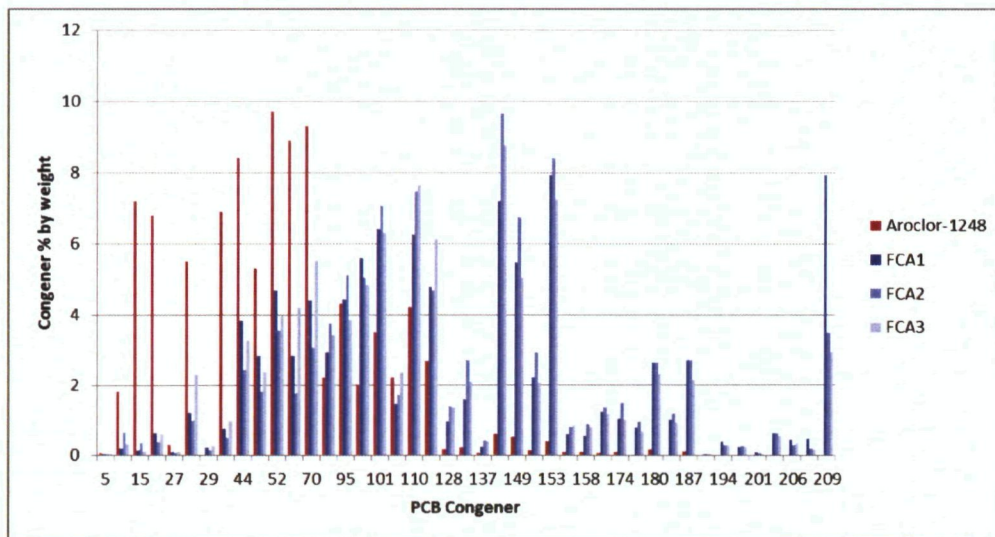


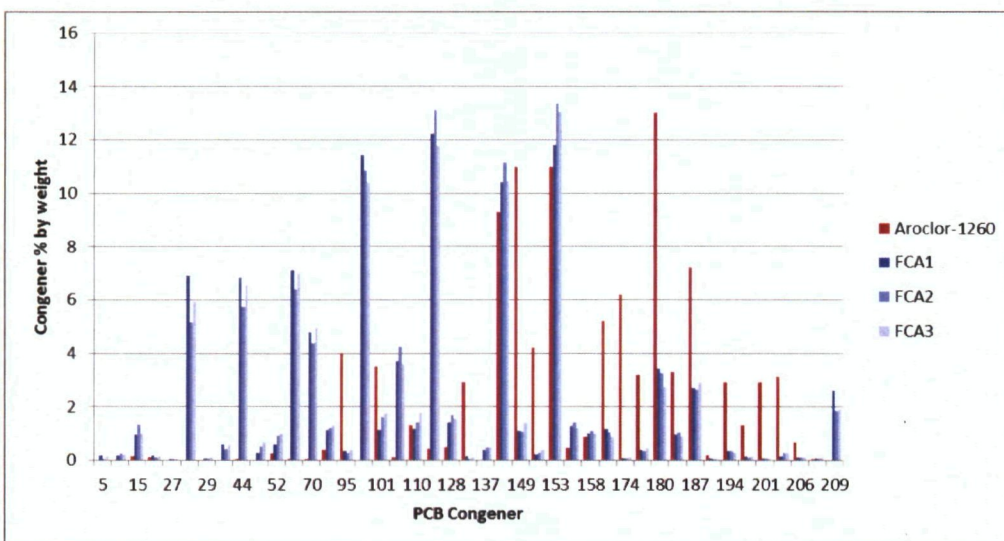
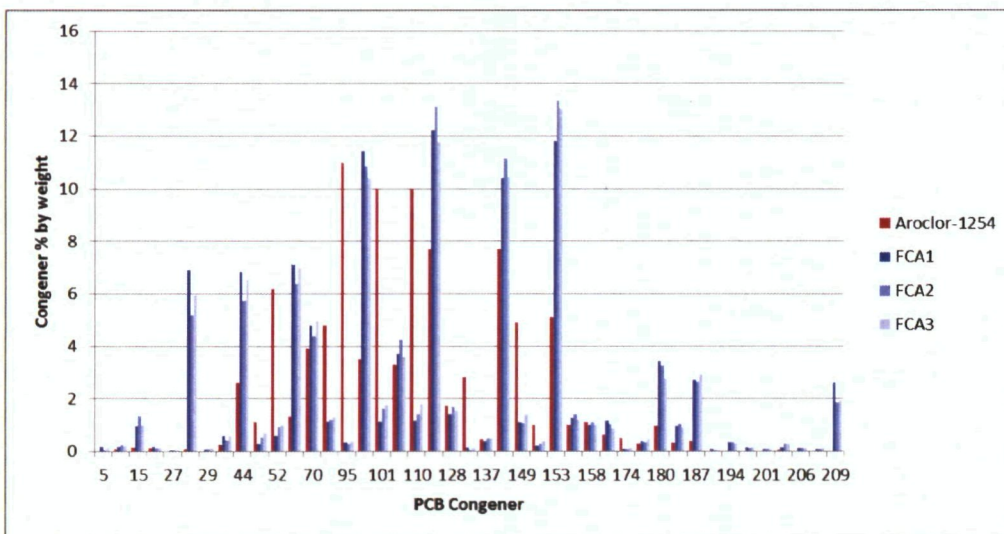
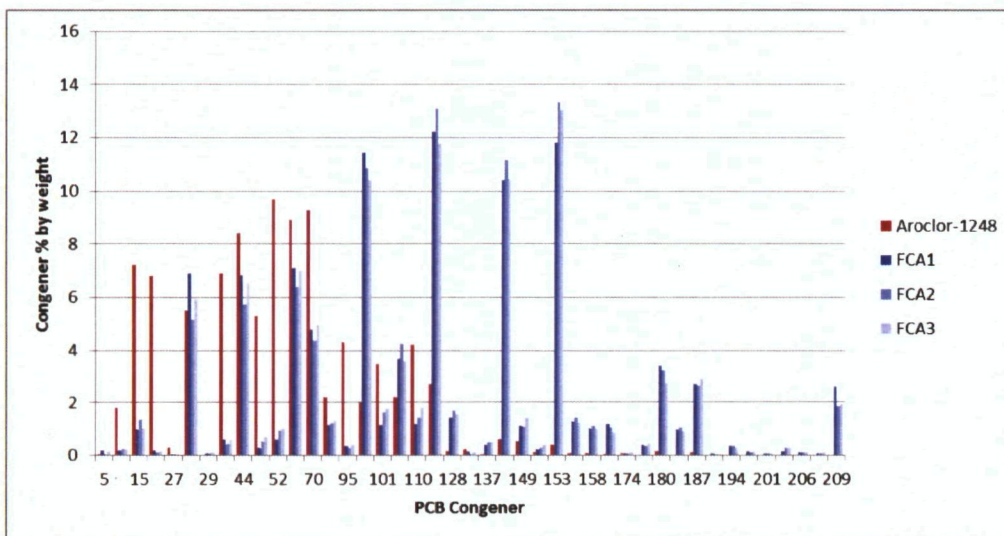
Figure 5-9

Dioxins and Furans in Fillet Fish, Historical Data  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site



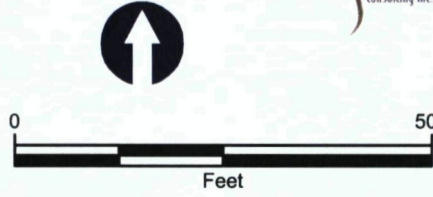








● Surface and Shallow Subsurface Soil Sample Locations

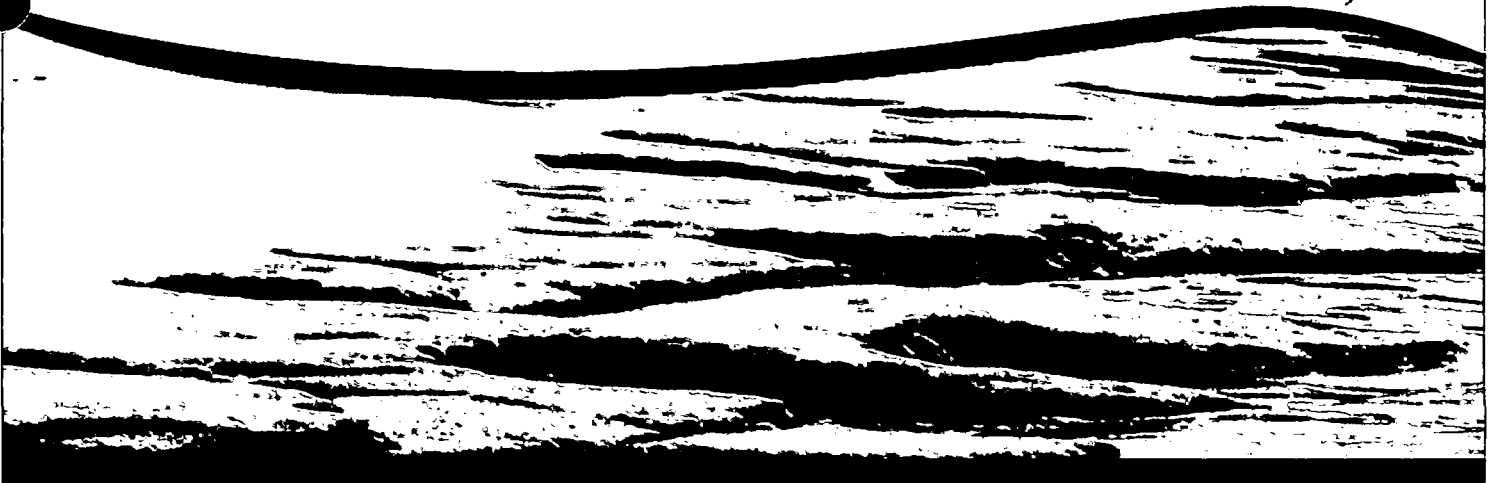


FEATURE SOURCES:  
Aerial Imagery: 0.5-meter 2008/2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIRIS

**Figure 6-1**  
Exposure Unit for Soils, Area of Investigation on the Peninsula South of I-10  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site

**APPENDIX A**  
**EXPOSURE ASSESSMENT**  
**MEMORANDUM**

---



## EXPOSURE ASSESSMENT MEMORANDUM SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

### **Prepared for**

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

### **Prepared by**

Integral Consulting Inc.

411 1st Avenue S, Suite 550

Seattle, Washington 98104

**May 2012**

# EXPOSURE ASSESSMENT MEMORANDUM SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

---

## **Prepared for**

McGinnes Industrial Maintenance Corporation  
International Paper Company  
U.S. Environmental Protection Agency, Region 6

## **Prepared by**



Integral Consulting Inc.  
411 1st Avenue S, Suite 550  
Seattle, Washington 98104

**May 2012**

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## LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
95UCL	95 percent upper confidence limit on the mean
ADD	average daily dose
BEHP	bis(2-ethylhexyl)phthalate
BHHRA	baseline human health risk assessment
COPC	chemical of potential concern
COPC <sub>H</sub>	chemical of potential concern to be addressed in the baseline human health risk assessment
CSM	conceptual site model
CT	central tendency
CTE	central tendency exposure
CWA	Coastal Water Authority
DQO	Data Quality Objective
EAM	Exposure Assessment Memorandum
EPC	exposure point concentration
FCA	fish collection area
IPC	International Paper Company
LADD	lifetime average daily dose
MIMC	McGinnes Industrial Maintenance Corporation
MWW	Mann Whitney Wilcoxon
NHANES	National Health and Nutrition Examination Survey
OEHHA	Office of Environmental Health Hazard Assessment
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo- <i>p</i> -dioxin
PCDF	polychlorinated dibenzofuran
PRA	probabilistic risk assessment
PSCR	Preliminary Site Characterization Report
RBA	relative bioavailability adjustment
RI/FS	Remedial Investigation and Feasibility Study

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RM	reasonable maximum
RME	reasonable maximum exposure
ROS	regression on order statistics
SALG	Seafood and Aquatic Life Group
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits site in Harris County, Texas
SJRWP	San Jacinto River Waste Pits
SWAC	surface weighted average concentration
TCEQ	Texas Commission on Environmental Quality
TCRA	Time Critical Removal Action
TDSHS	Texas Department of State Health Services
TEF	toxic equivalency factor
TEQ	toxicity equivalent
TEQ <sub>DF</sub>	toxicity equivalent for dioxins and furans
TEQ <sub>DFP</sub>	cumulative toxicity equivalent for PCBs and dioxins and furans
TEQ <sub>P</sub>	toxicity equivalent for polychlorinated biphenyls
TMDL	total maximum daily load
TOC	total organic carbon
UAO	Unilateral Administrative Order
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

---

## 1 INTRODUCTION

This technical memorandum was prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC; collectively referred to as the Respondents) in fulfillment of the 2009 Unilateral Administrative Order (2009 UAO), Docket No. 06-03-10, issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009 (USEPA 2009a), for the San Jacinto River Waste Pits (SJRWP) site in Harris County, Texas (the Site). The 2009 UAO directs the Respondents to perform a Remedial Investigation and Feasibility Study (RI/FS) for the Site, and to prepare a Baseline Human Health Risk Assessment (BHHRA). The UAO also directs respondents to prepare an Exposure Assessment Memorandum (EAM) prior to the BHHRA report to describe the exposure scenarios, assumptions, fate and transport models, and data that will be used in the exposure analysis.

This document fulfills the UAO requirement for the EAM, establishing the methods, assumptions and data that will be used to perform the human exposure assessment. It builds on the conceptual site models (CSMs) described in the Preliminary Site Characterization Report (PSCR) (Integral and Anchor QEA 2012) for the impoundments north of I-10 and surrounding aquatic environments (Figure 1) and the impoundment south of I-10 (Figure 2). Consistent with UAO requirements and the RI/FS Work Plan (Anchor QEA and Integral 2010), the specific topics addressed by this EAM include:

- Exposure pathways and scenarios to be addressed in the BHHRA
- Datasets and methods to be used for calculation of exposure point concentrations (EPCs)
- The exposure equations and assumptions to be used
- Considerations for application of probabilistic methods to the exposure assessment.

The RI/FS Work Plan also states that the EAM will provide summary statistics for each dataset to be used in the BHHRA, and calculate EPCs for each exposure medium. Summary statistics for individual datasets for which data are available are presented in the PSCR (Integral and Anchor QEA 2012). EPCs are not presented in this EAM but will be prepared

following USEPA review and approval of this document, which is a complete presentation of the data and all of the methods and assumptions that will be used to derive EPCs.

## 1.1 Site Setting

The Site consists of three impoundments, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that were disposed of in these impoundments. Two impoundments, together approximately 14 acres in size, are located on a 20-acre parcel immediately north of the I-10 Bridge and on the western bank of the San Jacinto River (Figure 3). Historical documents and aerial photographs indicate that an additional impoundment was constructed south of I-10, on the peninsula of land south of the 20-acre parcel. This impoundment was also constructed in the mid-1960s. It was used for disposal of paper mill waste similar to that disposed in the two impoundments north of I-10, and other anthropogenic wastes. Figure 3 shows the area within USEPA's preliminary Site perimeter, as presented in the 2009 UAO, with the specific area for the soil investigation south of I-10 noted.

A Time Critical Removal Action (TCRA) to address soils and sediments associated with the impoundments north of I-10 has been completed. Through the installation of geotextile and geomembrane underlayments and a granular cover, the TCRA stabilized the entire area within the 1966 perimeter of the impoundments north of I-10 (the TCRA Site) (Figure 3), abating any release of polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and any other chemicals of potential concern (COPCs) into the waterway from these impoundments until the Site is fully characterized and a final remedy is selected (USEPA 2010a). Fencing installed as part of the TCRA implementation additionally limits access to the impoundments north of I-10, areas to the immediate west of these impoundments, and the eastern shore of the San Jacinto River immediately adjacent to I-10. The Coastal Water Authority (CWA) also installed fencing along the western side of the road to the immediate east of the Site that limits access to the shoreline on the east side of the channel under the I-10 Bridge. The placement of fences is shown in Figure 4. The condition that resulted from the TCRA and the installation of fencing by CWA collectively are described in this document as the "post-TCRA" condition.

## 1.2 Purpose and Scope

This memorandum is intended to establish an approved set of methods and assumptions that will be used for quantifying potential exposures in the BHHRA. The approaches and methodologies presented in this EAM are consistent with Data Quality Objectives (DQOs) and related statements and information presented in the sediment, tissue and soil sampling and analysis plans (SAPs) for the Site (Integral and Anchor QEA 2010; Integral 2010a,b), and the RI/FS Work Plan (Anchor QEA and Integral 2010).

Comments from USEPA on this draft EAM will be incorporated into a final EAM that will ultimately be included as an appendix to the draft BHHRA Report, which is scheduled to be submitted to USEPA in July 2012. Ultimately, the methods and assumptions outlined and discussed in the final EAM will be used to estimate intakes of chemicals of potential concern to be addressed in the BHHRA (referred to as COPCHs herein) that will subsequently be combined with toxicity criteria to derive estimated risks and hazards at the Site. Toxicity criteria are discussed in detail in the Toxicological and Epidemiological Studies Memorandum (Integral 2012), which is under development on the same schedule as this document.

USEPA guidance requires that a remedial investigation include evaluation of baseline risks to human receptors. In this context, “baseline” refers to the conditions at the site before implementation of the remedy. As such, baseline conditions provide a point of reference for evaluation of the no-action alternative in the feasibility study, and for quantification of risk reduction that can be achieved by each of several remedial alternatives to be considered in the feasibility study. The “baseline” condition to be evaluated by the risk assessments is the pre-TCRA condition.

The implementation of the TCRA and installation of fencing by CWA, which occurred after the sediment and tissue sampling programs had been completed, has greatly limited access to the area, and significantly altered exposure potential for all of the human receptors to be addressed in the BHHRA. Therefore, whenever relevant, analysis of exposure and risk will recognize both pre-TCRA and post-TCRA conditions. Evaluating the differences in risk between the pre-TCRA (baseline) and post-TCRA conditions is necessary for a complete

analysis of costs and benefits associated with each of the remedial alternatives considered by the feasibility study in development of the final remedy.

The evaluation of post-TCRA conditions will prioritize the analysis of dioxins and furans, which have been established as an indicator chemical group for the Site (Anchor QEA and Integral 2010). An indicator chemical or chemical group is one that is the most toxic, persistent, and/or mobile among those substances likely to contribute significantly to the overall risk at a site (USEPA 1988). USEPA (1988) guidance recognizes that the use of a properly selected indicator chemical or group reduces both the time and costs of developing remedial approaches. As summarized in Appendix C of the RI/FS Work Plan, concentrations of dioxins and furans relative to risk-based screening values are very high in sediments from the impoundments north of I-10, and the degree to which they exceed risk-based screening levels in these sediments relative to those of the other COPCs is also very high, indicating that they are very likely to be the most important risk driver at the Site. Therefore, the focus on dioxins and furans for the post-TCRA evaluation will enable description of the differences between pre-TCRA (baseline) and post-TCRA exposure potential.

### **1.3 Document Organization**

USEPA (1989) defines three main steps to the exposure assessment process:

1) characterization of the exposure setting, 2) identification of exposure pathways, and 3) quantification of exposure. The first two components of this process have been addressed and are presented within documents related to the RI/FS being conducted for the Site. These are summarized in Section 2. The third step will be performed for the BHHRA, according to methods described in Sections 2 through 5.

This document is organized as follows:

- Section 2. Exposure pathways and scenarios
- Section 3. Datasets and methods used for calculation of EPCs
- Section 4. Exposure equations and parameters
- Section 5. Implementation of probabilistic exposure assessment
- Section 6. Summary
- Section 7. References.

It also includes the following appendices:

- Appendix A. Quality Assurance Review, PCB Congener Data from the TMDL Program
- Appendix B. Historical Fish Tissue Data
- Appendix C. Results for Statistical Comparisons of FCAs
- Appendix D. Detection Frequencies for Sediment, Tissue, and Soil Exposure Units
- Appendix E. Contribution of Individual Dioxin Congeners to TEQ<sub>DF</sub> in Tissue.
- Appendix F. EPA Comments Relating to the Draft Exposure Assessment Memorandum, and Responses

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## 2 EXPOSURE PATHWAYS AND SCENARIOS

Consistent with the RI/FS Work Plan (Anchor QEA and Integral 2010) and the PSCR (Integral and Anchor QEA 2012), the exposure assessment will be based on two CSMs. A CSM describes the sources, release mechanisms, distribution and transport pathways of chemicals to potential receptors. Exposure pathways link sources of COPCs to potential receptors and define those links in terms of specific exposure routes; an exposure route is the physical way in which human receptors may come into contact with chemicals present in exposure media (i.e., ingestion, dermal absorption, inhalation). Exposure pathways are considered potentially complete and significant if the exposure occurs frequently over an extended duration and/or the exposure medium represents a significant potential source of site-related contaminants to the receptor. Exposure pathways are considered potentially complete but minor if the exposure medium represents a relatively minor potential source of site-related exposure to a chemical, and/or potential for contact to the medium is limited. The relative importance of each pathway and route is relevant because pathways that are considered potentially complete and significant are those that provide the greatest risk reduction when addressed by remedial action.

This section reviews the two CSMs for the Site and describes the exposure scenarios and pathways to be addressed in the BHHRA. One CSM describes the area north of I-10 and includes the aquatic environment (Figure 1). The other describes the area of the south impoundment (Figure 2). As described in the RI/FS Work Plan (Anchor QEA and Integral 2010), exposure pathways that are potentially complete and significant will be evaluated quantitatively.

Exposure pathways that are defined as potentially complete but minor will be evaluated qualitatively in the BHHRA. The manner in which minor pathways will be discussed is described below.

Data and methods for quantifying exposures to complete and potentially significant pathways are described in Sections 3 and 4 below.

## 2.1 Area North of I-10 and Aquatic Environment

In addition to the overall Site CSM, a detailed description of the expected exposure routes are shown in Figure 5 for each of the receptors, fishers, recreational visitors, and trespassers. The receptors shown in this CSM have been identified as those with potentially complete exposure pathways for the area north of I-10 and the aquatic environment (Anchor QEA and Integral 2010; Integral 2011a). The following potential exposure routes are identified in the CSM exposure diagram for human receptors for the area north of I-10 and aquatic environments (Figure 5):

- Ingestion of and dermal contact with chemicals in sediments
- Dermal contact with chemicals in porewater
- Ingestion of and dermal contact with chemicals in surface water
- Ingestion of fish and shellfish
- Ingestion of and dermal contact with chemicals in soils
- Inhalation of chemicals in air (i.e., gases or particulates).

For the fishers and recreational visitor, potentially complete and significant exposures to Site media are expected to occur via direct contact with sediments or soil (via ingestion and dermal contact) and, for the fishers, also through ingestion of aquatic organisms (i.e., fish and shellfish) that contain Site-related contaminants. While a Site trespasser would be exposed via the same pathways as the recreational visitor (i.e., direct contact pathways) and recreational fisher (i.e., ingestion of fish and shellfish), the trespasser exposure would likely be intermittent and shorter term than the exposures being evaluated for those scenarios. These pathways are considered to be minor pathways in the CSM. Therefore, this scenario will not be evaluated in a quantitative manner for the area north of I-10. A discussion of the exposure that would be anticipated for the trespasser relative to exposures calculated for the recreational visitor and recreational fisher will be included in the BHHRA.

Individuals may also be exposed to COPCs through direct contact (ingestion and dermal) with surface water and sediment porewater, or through inhalation of COPCs as particulates or vapors in air, but exposures via these media and routes are considered to be minor. For pathways leading to inhalation exposure, designation as minor is consistent with standard exposure assumptions used for determining residential and industrial soil screening levels, for

which inhalation contributes less than 1 percent of the total exposure via all direct pathways (including ingestion via soil and dermal contact with soils) to the nonvolatile COPCHs present at the Site (USEPA 2011a). Moreover, the Draft Public Health Assessment for the Site (TDSHS 2011) also considered direct exposure to surface water and inhalation of COPCHs in air to be minor pathways.

Consistent with the RI/FS Work Plan (Anchor QEA and Integral 2010), minor pathways will be discussed qualitatively in the BHHRA. This discussion will use information about the physical-chemical properties of the COPCs to describe the likely extent of their presence in media for which exposures are considered minor. Evaluation of minor pathways will also include a description of the likelihood, frequency, and intensity with which exposures via minor pathways and routes are anticipated to occur at the Site for each receptor. Relevant information from the peer-reviewed literature and risk assessments from other sites, if available, will also be summarized. These lines of evidence will be combined to define the importance each minor pathway relative to the pathways defined as potentially complete and significant.

## 2.2 South Impoundment Area

The area south of I-10 is developed and managed for commercial and industrial activity. Industrial workers and trespassers are the human receptors with potential for exposure in this area (Integral 2011b). The following potential exposure routes for human receptors are considered in the CSM exposure diagram for human receptors for the south impoundment area (Figure 6):

- Ingestion of and dermal contact with chemicals in soils
- Inhalation of chemicals in air (i.e., gases or particulates).

Potentially complete and significant exposures for workers and trespassers to Site media in the south impoundment area are expected to occur via direct contact with soil (via ingestion and dermal contact). As presented above for the north impoundment area, exposures via inhalation are considered to be minor, and will be discussed qualitatively.

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### **3 DATASETS AND METHODS FOR CALCULATION OF EXPOSURE POINT CONCENTRATIONS**

CERCLA guidance (USEPA 1988) states that a baseline risk assessment is performed to identify the existing or potential risks at a site, support a determination of whether remediation is needed, and serve as the basis for the evaluation of the effectiveness of any subsequent remedial action. Determination of an appropriate baseline dataset is therefore a key step in the RI/FS process.

Characterization of the background condition provides context to the evaluation of onsite conditions. The background dataset effectively represents the exposure condition in the absence of contributions from a site. Comparison of onsite and background-related exposure allows evaluation of the additional, incremental exposure and risk presented by chemicals of concern that are attributable to a site. For chemicals with high background concentrations, characterization of background exposures and risks is recommended by USEPA (2002a) if data are available.

To organize the baseline dataset for use in exposure assessment according to specified exposure scenarios, exposure units are identified, and EPCs are calculated for each exposure medium within each exposure unit. An exposure unit is defined as the area throughout which a particular receptor moves and encounters an environmental medium for the duration of the exposure (USEPA 2002b). An EPC is a conservative estimate of the chemical concentration in an environmental medium (USEPA 1989, 2002b) that may be contacted by the human receptor. In human health risk assessment, the EPC may be represented as the central tendency (CT) of the dataset for an exposure unit, or as the reasonable maximum (RM) concentration. In either case, the CT or RM concentration is calculated using a statistic that is appropriate to the distribution of the data (e.g., maximum or 95 percent upper confidence limit on the mean [95UCL] for the RM). EPCs are determined for individual exposure units within a site.

This section first identifies the COPCHs to be addressed, the baseline data to be used for the BHHRA, and the dataset to characterize the background exposure conditions, and the data treatment rules that will be applied to the data. Next, it presents the methods for the

analyses used to define the medium-specific exposure units, and results of that evaluation. Finally, it presents the methods that will be used to calculate EPCs for each individual exposure unit.

### **3.1 Chemicals of Potential Concern**

COPCHs have been identified according to steps described by the RI/FS Work Plan (Anchor QEA and Integral 2010) and the Sediment SAP (Integral and Anchor QEA 2010). Analyses of the sediment data according to methods described in the Sediment SAP are documented in the COPC Technical Memorandum (Integral 2011a) and resulted in determination of the final list of COPCHs for the area north of I-10 and the aquatic environment (Table 1). Selection of COPCHs for the south impoundment area is in progress. According to a comparison of the Phase I soil investigation results to risk-based human health screening levels protective of workers, only detected TEQ<sub>DF</sub>, arsenic, and thallium exceeded screening concentrations in any surface and subsurface samples for which they were analyzed (Integral 2011c, Attachment A).<sup>1</sup> Although thallium is not a COPCH according to analyses of information for the north impoundment, it may be determined to be a COPCH for the south impoundment, and is therefore addressed in this memorandum and listed in Table 1. Any COPC (see Table 2) in addition to those in Table 1 that becomes a COPCH for the south impoundment and impact the content of this EAM will be addressed as an attachment to the final EAM, which will be an appendix to the BHHRA Report.

### **3.2 Data**

To evaluate the potential exposure via pathways outlined in the two CSMs, data for sediment, fish and shellfish tissue, and soils are required. Identification and organization of representative data for calculation of EPCs for the BHHRA involves determination of the baseline dataset for the Site and the dataset to be used to represent background conditions. Selected data should be representative of the sediment, soils, and tissue to which people may be exposed.

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<sup>1</sup> Total PCB concentrations were calculated as the sum of Aroclors with nondetects substituted at one-half the detection limit. High-biasing nondetects, or those results for which the detection limit was greater than the maximum detected concentration, were excluded from the analysis. Both of these steps are consistent with the data management plan for this Site (see Appendix A of the RI/FS Work Plan) and consistent with the data treatment rules established in the PSCR, and outlined in Section 3.3 below.

Available data to be used in the BHHRA to evaluate exposure are summarized in Table 3 and discussed below. The determination of the specific exposure scenarios and pathways for which background risk calculations will be conducted will depend on the results of the assessment of Site-related risks. For this memorandum, the complete set of available background data that may be considered for quantitative evaluations within the BHHRA is presented, even though background risks may not be relevant for all media. This section first describes the datasets to be used for both the Site-related and background exposure assessments. A description of the data types to be used follows. The specific data that will be used to evaluate each exposure pathway under each exposure scenario are described in Section 4 in the context of the individual receptor groups.

### **3.2.1 Baseline Risk Assessment Datasets**

The PSCR establishes the baseline dataset for the Site, and related information is reviewed below. This memorandum adds to the baseline dataset discussed in the PSCR by addressing tissue and sediment samples collected by the Texas Commission on Environmental Quality (TCEQ) in 2008 and 2009 and analyzed for polychlorinated biphenyls (PCBs). Background data for use in the baseline risk analyses are also discussed in this section.

#### **3.2.1.1 Baseline Data for the Site**

According to the PSCR and CERCLA guidance (USEPA 1988), data used in the baseline risk assessment should represent current conditions. Because risk management decisions will stem from the baseline risk assessment, the data used should also be of known and acceptable quality. As described in the RI/FS Work Plan (Anchor QEA and Integral 2010), Category 1 data are of known quality and are considered to be acceptable for use in decision-making for the Site, and only Category 1 data will be considered for quantitative risk analysis in the BHHRA.

A comparative analysis of the 2005 and 2010 surface sediment data from the area surrounding the northern impoundments is presented in Section 3 of the COPC Technical Memorandum (Integral 2011a). The analysis demonstrated that there were significant differences in dioxin and furan concentrations in surface sediment between 2005 and 2010. It

concluded that the sediment data from 2005 was not representative of current conditions, and that it should therefore not be included in the baseline dataset. Although the cause of the difference is unknown, this analysis provided a useful benchmark for all of the datasets, assuming that changes in sediment conditions also represent changes in overall conditions for other media. On this basis, the PSCR establishes that none of the data collected in 2005 or earlier should be considered part of the baseline dataset.

The draft PSCR indicates that additional data recently generated by TCEQ's Total Maximum Daily Load (TMDL) program for PCBs will be included in the BHHRA if the data can be independently validated, as prescribed by Section 3 of the RI/FS Work Plan. Following publication of the draft PSCR, additional data for PCB congeners in tissue and sediment collected both on the Site and elsewhere as part of TCEQ's TMDL program (University of Houston and Parsons 2009; Koenig 2010, pers. comm.) have been independently validated according to procedures described in the RI/FS Work Plan. Specifically, the data for PCB congeners in tissue and sediment collected by TCEQ in 2008 and 2009 have been reclassified as Category 1 data following independent validation. These include tissue and sediment data from a single sample location (Station 11193) within the preliminary Site boundary and tissue data from several background locations (discussed below). As a result, these data can be used in the BHHRA. A report documenting the independent validation of these data is provided as Appendix A.

As a result of these considerations, the baseline dataset for the Site consists of:

- Sediment, tissue, and soil data collected for the RI/FS, including soil from the south impoundment planned for collection in February 2012<sup>2</sup>
- Sediment and water data collected by URS (2010) for the TCEQ in 2009.
- PCB congener data for fish tissue and sediments resulting from sampling conducted by TCEQ in 2008 and 2009.

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<sup>2</sup> Planned sampling is documented in draft Addendum 3 to the Soil SAP for additional soil sampling south of I-10 (Integral 2011c)

At the request of USEPA (Miller 2011, pers. comm.), Category 2 tissue data available from 2005 and prior are included in Appendix B. These data will not be used to derive EPCs for the BHHRA because they are outdated and are of unknown quality.

### **3.2.1.2 Background Data**

Comparison of Site-related risks to background risks will not necessarily be conducted for all exposure scenarios, environmental media, or COPCHS. Rather, the comparison will be completed only for those scenarios and pathways that result in unacceptable Site risks and for which relevant background data are available. It is expected that ingestion of fish and/or shellfish by fishers will be an exposure pathway resulting in unacceptable risks at the Site. The potential for fish and crabs to move around the bay and be influenced by sources that are unrelated to the Site means that chemical concentrations found in edible tissues may be obtained from a combination of Site- and non-Site-related sources. Analysis of background information allows for consideration of other sources of risks at the Site, which is relevant to both risk assessment and evaluation of remedial alternatives. This context ensures that any remedial actions that may be taken at the site to reduce risk will actually result in reduction of exposure and risk originating from Site-related sources and is therefore relevant to risk management at the Site. Background data used for this purpose should also be representative of environmental media that people may actually contact, and provide a reasonable temporal match to the Site data. Background datasets for the BHHRA include:

- Sediment, tissue, and soil data collected for the RI/FS in background areas
- Tissue data collected by TCEQ as part of the TMDL program from stations downstream of the Site and in proximity to the Fred Hartman Bridge that have been reclassified as Category 1 data following independent data validation (Appendix A).

### **3.2.2 Data Types**

The data types to be used to characterize each medium are discussed briefly below.

### 3.2.2.1 *Sediment*

Fishers and recreational visitors have potential for exposure to surface sediment in accessible shoreline areas of the Site. There is a limit, however, to the water depth into which these individuals will wade during these activities. To determine the boundary of the sediment that may result in direct contact exposures, Site bathymetry contours were mapped. The 2-foot depth contour (i.e., sediment covered by 2 feet of water or less) was considered the outer boundary of sediments that people using the Site may contact directly.<sup>3</sup> All shoreline and near-shore sediment data covered by 2 feet of water or less will be used to calculate EPCs for sediment for the fishing and recreational scenarios. As outlined in the Sediment SAP (Integral and Anchor QEA 2010) sediment samples collected from the 0- to 6-inch depth increment will be used to evaluate exposure to humans.

### 3.2.2.2 *Tissue*

Fishers may catch and consume finfish and/or shellfish from within the Site perimeter. The available tissue data include hardhead catfish fillet (skin removed), edible crab tissues, and edible clam tissues, which were collected to evaluate potential human exposures (Integral 2010a). A small amount of hardhead catfish (skin removed), data from TCEQ's TMDL program investigations also meet the data quality and temporal criteria for consideration in the quantitative BHHRA (Appendix A). Hardhead catfish fillet data will be used to estimate exposures through ingestion of finfish. Edible crab and clam tissues will be used to estimate exposures to shellfish.

There is uncertainty regarding the representativeness of available fish tissue data for characterizing actual exposures via ingestion that could potentially occur at the Site. This is because there is no Site-specific information regarding the extent to which various fish and shellfish types are collected from the Site and consumed, and only data for hardhead catfish, blue crab, and clams are available in the baseline dataset.

The use of hardhead catfish to represent all human exposure to finfish results in a conservative upper-end exposure for fishers consuming finfish from the Site. This is because

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<sup>3</sup> The tidal condition at which the 0 foot contour was established is not known. This results in some uncertainty in the determination of sediment locations that are representative of human exposure.

hardhead catfish are benthic fish, which typically have higher concentrations of dioxins and furans than fish living and feeding in the water column within the same waterbody (e.g., USEPA 2009c). In addition, TCEQ's TMDL data for dioxins and furans in tissue indicate that other recreationally caught species generally have lower concentrations of dioxins and furans (as TEQ<sub>DF</sub>) than hardhead catfish (Appendix B).

Uncertainties associated with the representativeness of tissue data designated for the BHHRA will be explored in the uncertainty evaluation completed as part of the BHHRA. Available information on species preferences described in the RI/FS Work Plan (i.e., Beauchamp 2010, pers. comm.) and from a study completed in Lavaca Bay (Alcoa 1998), and the impact of differing assumptions about the consumption of other species on risk estimates will be presented as part of this evaluation.

### 3.2.2.3 Soils

Fishers and recreational visitors have potential for exposure to soils in the area north of I-10, while trespassers and workers may be exposed to soils in the south impoundment area. Individuals who use the Site are anticipated to participate in activities that would potentially bring them into contact with surface soils. Site workers may additionally have contact with shallow subsurface soils during outdoor maintenance activities.

Under the soil investigations completed for the remedial investigation, soil from a variety of depth increments has been collected for each area and analyzed for COPCHs (Integral and Anchor QEA 2011). At locations north of I-10, these include:

- Co-located surface and shallow subsurface soils from 0 to 6 and 6 to 12 inches
- Surface soils from 0 to 8 and 0 to 12 inches
- Deep subsurface soils from 12 to 24 inches
- Soil cores from 48 to 60 inches.

At locations south of I-10, available soil samples include:

- Co-located surface and shallow subsurface soils from 0 to 6 and 6 to 12 inches
- Deep subsurface soils from 12 to 24 inches
- Soil cores in 2-foot intervals which include samples from the surface at 0 to

24 inches.

Additional co-located surface and shallow subsurface samples, and deeper soil cores within the south impoundment area were collected in April, 2012 (Integral 2011c).

Among these soil data, those for soils representing the surface condition (i.e., those collected from surface increments of 0 to 6, 0 to 8, 0 to 12, and 0 to 24 inches) will be used to evaluate exposure for fishers, recreational visitors, and trespassers. For Site workers in the south impoundment area data from these increments, as well as from the shallow subsurface increment of 6 to 12 inches will be used. For locations at which data for both 0- to 6- and 6- to 12-inch soils are available, depth-weighted average concentrations will be calculated for each sample location to represent the 0- to 12-inch interval, and will be used in the EPC calculation. The equation for calculating depth-weighted concentrations is provided below in Section 3.5.1.

### **3.3 Data Treatment**

Data treatment rules outlined in the Project Data Management Plan (Appendix A of the RI/FS Work Plan) will be followed. The data plan includes rules for handling field duplicates, field splits, and laboratory replicate pairs.

Following USEPA (1989) guidance, for any  $COPC_H$  detected at least once in a given medium, nondetected results that exceed the highest detected concentration will be excluded prior to calculation of EPCs. All other nondetected results that are within the range of detected concentrations will be retained and addressed as described below.

The RI/FS Work Plan for the Site further specifies the manner in which nondetected data will be treated. It specifies that two approaches will be used for handling nondetected results in the calculation of toxicity equivalent concentrations for dioxin-like PCB congeners ( $TEQ_P$ ) and for dioxins and furans ( $TEQ_{DF}$ ). Under the first approach nondetected results will be assumed to be equal to one-half of the estimated detection limit for each congener prior to multiplication of the appropriate toxicity equivalency factor (TEF) (see Table 4). Under the

second approach, nondetected results will be assigned a value of zero, and incorporated into the TEQ. The results of both approaches will be presented in the risk assessment.

For calculation of concentrations of COPCHs other than dioxins and furans and dioxin-like PCBs, consistent with USEPA's QA/G-9 guidance (USEPA 2000b), nondetected results will be addressed considering the size of the dataset and the detection frequency. The following rules for handling nondetected values will be employed:

- For datasets with 10 or more samples ( $N \geq 10$ ) and a detection frequency of 50 percent or more ( $\geq 50$  percent), nondetected values will be substituted with one-half the detection limit.
- For datasets in which  $N \geq 10$  and the detection frequency is between 20 and 50 percent<sup>4</sup>, robust regression on order statistics (ROS) (Helsel 2005) will be used to generate values for nondetected values.
- For datasets with  $N < 10$ , regardless of the detection frequency, or with a detection frequency of less than 20 percent, regardless of sample size, nondetected values will be treated as one-half the detection limit. In these instances, nondetected values will not be estimated using ROS because the pool from which information about the data distribution can be drawn is insufficient for robust substitution methods.

Consistent with comments received from USEPA on the Tissue SAP (Integral 2010a, Appendix C), total PCBs in tissue will be calculated as the sum of 43 PCB congeners specified. The 43 specific congeners to be included are shown in Table 5. In cases in which additional PCB congeners co-elute with the 43 specified, these congeners will also be included in the sum for total PCBs. For the remedial investigation tissue and TMDL tissue datasets, these additional congeners to be included in the total PCB calculation are as follows: PCB-20, -30, -47, -61, -65, -69, -76, -83, -86, -90, -97, -109, -113, -115, -125, -129, -135, -163, -166, and -193. Their inclusion results in a sum that is biased high compared to the sum of the 43 congeners requested. The impact of this uncertainty on the overall risk estimate will be considered in the uncertainty evaluation for the BHHRA.

<sup>4</sup> Some flexibility will be applied around these limits. In the case that the dataset follows a distribution that reasonably supports substitution methods, such methods may be applied.

Consistent with USEPA guidance (2010b) and the approaches taken by the Texas Department of State Health Service's (TDSHS) Seafood and Aquatic Life Group (SALG) (TDSHS 2008), 100 percent of mercury detected in tissue will be evaluated as methylmercury. For soil and sediment, it will be assumed that 100 percent of mercury detected is in an inorganic form. Consistent with the state of knowledge regarding the proportions of inorganic and organic arsenic in fish tissues (USEPA 2003; ATSDR 2007) and approaches taken by TDSHS's SALG (TDSHS 2008), 10 percent of arsenic detected in tissue will be assumed to be inorganic arsenic. The remaining 90 percent will be assumed to be in an organic form. One hundred percent of the arsenic measured in soils and sediments will be assumed to be inorganic arsenic.

### **3.4 Exposure Units**

According to USEPA Guidance (2002b), an exposure unit is an area throughout which a particular receptor moves and encounters an environmental medium for the duration of the exposure. Exposure units are thus intended to have a conceptual basis in the physical environment corresponding to an area within which receptor groups may come into contact with COPCs, and provide a physical frame of reference for describing risk. In this way, identification of exposure units facilitates risk management and future land use decision-making because the risk evaluation, which addresses each exposure unit, is then tied to a specific geographical area within which COPCs occur (USEPA 2002b; Anchor QEA and Integral 2010).

Selection of exposure units should also consider the statistical characteristics of the datasets (USEPA 2002b). Where concentrations of COPCs in environmental media vary within the site boundaries, exposure units are selected to allow the risk assessment to distinguish between areas on the Site with higher levels of risk and/or hazard to people from those areas with lower exposure and risk. Such a distinction also facilitates risk management decisions by indicating which areas are associated with the highest risk, and therefore which areas should be prioritized in remediation planning.

Statistical analyses are used to determine when different areas of the Site have significantly different COPC concentrations for a given medium. When the concentrations of any given COPC in different areas are not statistically different from each other, data for that COPC in that environmental medium can be pooled, which increases the statistical power of the resulting EPC. When data are pooled, the resulting statistic (e.g., 95UCL) represents the EPC for each of the physical areas of the site that is included in the pooled data.

This section describes the process for identification of exposure units for the following exposure media:

- Sediments from within the 1966 impoundment perimeter north of I-10 and aquatic environments of the Site
- Edible crab, catfish fillet, and clam tissue
- Soils for the area north of I-10
- Soils for the south impoundment area.

The data evaluations were conducted as described in the DQOs of the Tissue SAP (Integral 2010a). Exposure units representing both pre-TCRA and post-TCRA conditions are described. The specific samples to be used to calculate EPCs for each exposure unit are described in Table 6.

### **3.4.1 Exposure Units for Sediments**

The determination of exposure units for sediments for the BHHRA follows the DQOs established in the Sediment SAP. Because the TCRA prevents contact with some sediments from on the Site, pre- and post-TCRA exposure units are relevant for sediments and are discussed below.

#### **3.4.1.1 Pre-TCRA**

As described in the COPC Technical Memorandum (Integral 2011a), sediment samples from five shoreline beach areas were collected to be used in characterization of human exposures. Following methodologies outlined in the Sediment SAP to evaluate the statistical similarities of COPC<sub>H</sub> concentrations in these areas, these areas were grouped into four separate exposure units. As described in the COPC technical memorandum, these are Beach Area

A—the shoreline to the west of the shipping berth on the property west of the impoundments; Beach Area B/C—the eastern shoreline of the sand separation area and the shoreline between the sand separation and west side of the impoundments; Beach Area D—the shoreline on the east side of the channel under the I-10 Bridge, and downstream; and Beach Area E—the shoreline of the river channel at the southeast corner of the waste impoundments. The sample locations associated with each of these four units are described in the COPC Technical Memorandum (Integral 2011a). In addition to the sediment sample locations described in that analysis, which were those proposed specifically to evaluate human exposures, 10 additional sample locations in the area of the impoundment (i.e., Beach Area E) were determined to be appropriate for evaluating human exposures in this area. These samples will be included within the Beach Area E exposure unit. In total, four sediment exposure units are defined.

The exposure units defined for evaluating pre-TCRA exposure conditions are shown in Figure 7. The environmental data for the exposure units are described in Table 6.

#### **3.4.1.2      *Post-TCRA***

Fencing installed as part of the TCRA and by CWA limits land access to the shoreline surrounding the former northern impoundment, the area directly west of that impoundment, and on the east side of the channel beneath the I-10 Bridge. For the BHHRA, it will be assumed that fishers will not access these shorelines via boat, and therefore access to these areas will be completely restricted. In addition, the TCRA cap itself eliminates the potential for direct contact with materials within the original 1966 impoundment perimeter north of I-10. Therefore, under post-TCRA conditions, only the sediments in Beach Area A will be considered.

The exposure units defined for evaluating post-TCRA exposure conditions are shown in Figure 8. The perimeters of the fencing constructed as part of the TCRA and by CWA are also shown. Available environmental data for the areas are described in Table 6.

### **3.4.2 Exposure Units for Tissue**

Hardhead catfish fillet, edible clam tissue, and edible crab tissue were collected from three fish collection areas (FCAs) as part of the remedial investigation (Integral 2010a; Integral and Anchor QEA 2012). Two FCAs are located north of I-10 and one south of I-10 (Figure 9). As described in Section 3.2 above, a few of the finfish samples collected on the Site in TCEQ's PCB TMDL study meet the data quality and temporal criteria for inclusion in the quantitative risk assessment (Appendix A) and will also be included in the dataset.

No tissue data exist that are representative of the post-TCRA condition at the Site. Therefore, representative tissue concentrations will be modeled using statistical relationships between Site sediment and tissue established in the Technical Memorandum on Bioaccumulation Modeling (Integral 2011d), or related methods. The sediment concentration used in such a modeling effort will be the post-TCRA surface-weighted average concentration (SWAC) in the sediment, calculated using data from within the tissue exposure unit.

#### **3.4.2.1 Pre-TCRA**

The analysis completed to identify exposure units for tissues for the BHHRA is presented below. The analysis described below follows the DQOs established in Section 1.8.3 of the Tissue SAP (Integral 2010a) and uses the hardhead catfish fillet, blue crab, and clam tissue data described above in Section 3.2.

##### **3.4.2.1.1 Methods**

Following the approach outlined in the Tissue SAP DQOs, analyses were carried out to determine whether, for each tissue type, data from the different FCAs could be pooled to represent a single exposure condition. Tissue chemistry data for datasets that are not significantly different were pooled. Nonparametric statistical tests were used because of the small sample sizes for the individual datasets and areas being compared (i.e., a maximum of 10 composite tissue samples per group). The following analyses were completed sequentially.

To determine whether historical data from the TMDL program for PCBs could be pooled with PCB data collected as part of the remedial investigation both non-statistical and

statistical evaluations were undertaken. First, the ranges of total PCBs (as the sum of the 43 relevant congeners of interest described in Section 3.3) in the two geographically related datasets were examined side by side. In the case that the ranges showed no overlap, the datasets are not considered to be of the same sample population. If they did show an overlap in concentrations, a nonparametric (Mann Whitney Wilcoxon [MWW] test) was run to test the null hypothesis of equivalence. Statistical significance was evaluated at  $\alpha = 0.05$ . Groups of samples of the same tissue type from different studies that were not significantly different were pooled.

To determine whether data from the three FCAs represent equivalent exposure conditions, nonparametric tests to evaluate the null hypothesis of equivalence for each COPCH in each edible tissue type were conducted. For each edible tissue type, and each pair-wise combination of FCAs, a Mann Whitney U test was used to compare each COPCH between FCAs. Statistical significance was evaluated at an overall  $\alpha$  of 0.05; individual COPCHs were evaluated at an adjusted  $p$ -value, using the Bonferroni correction for multiple comparisons (USEPA 2009b). For hardhead catfish and clam, in which nine COPCHs were detected,<sup>5</sup> an adjusted  $p$ -value of 0.0056 was employed. For blue crab, in which eight COPCHs were detected,<sup>6</sup> an adjusted  $p$ -value of 0.0063 was employed. If differences for any COPCH in pair-wise FCA comparisons were statistically significant, the FCAs are considered different and the data were not pooled. FCAs that were not significantly different were combined into a single exposure unit for all COPCHs. For cases where non-transitivity<sup>7</sup> arose from the results, and alternative pooling approaches could be used, additional analyses were carried out to determine whether either of those approaches were preferred.

Lastly, the appropriateness of pooling data for different tissue types was considered. The equivalence of the pooled FCAs for each tissue type (as a result of the analyses above) and the manner in which representative concentrations of COPCHs in various types of tissue will be combined with other exposure parameters to estimate intake in the BHHRA were considered.

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<sup>5</sup> BEHP was not detected in hardhead catfish fillet or clam tissue.

<sup>6</sup> BEHP and nickel were not detected in edible blue crab tissue.

<sup>7</sup> If two areas are each equivalent to a third area but they are not equivalent to each other, then the results of the two-sample tests are not transitive.

### 3.4.2.1.2 Results

The stepwise analysis outlined above supported the pooling of hardhead catfish fillet data for PCBs from the TCEQ TMDL program with hardhead catfish fillet data collected from FCA 1 for the remedial investigation. It additionally supported pooling hardhead catfish fillet data for all COPCHs in FCA 2 and 3, blue crab data for all COPCHs in FCA 2 and 3, and clam data for all COPCHs in FCA 1 and FCA 3. Results for each of the statistical comparisons are detailed in Appendix C and discussed briefly below.

#### ***Pooling Data from the TMDL PCB and Remedial Investigation Studies***

Three hardhead catfish fillet samples collected as part of TCEQ's TMDL program and 10 hardhead catfish fillet samples collected for the remedial investigation were collected from within FCA 1. The maximum concentration for the sum of the 43 PCB congeners of interest for the TMDL PCB samples was slightly higher than the maximum concentration from the catfish collected from FCA 1 as part of the remedial investigation, but the majority of each distribution overlapped the other (TMDL total PCB: 48.9 to 156  $\mu\text{g/kg}$  (N=3); RI, FCA1: 18.2 to 132  $\mu\text{g/kg}$  (N=10)). Given the considerable overlap in the ranges, the hardhead catfish fillet data from the two studies were tested for equivalence. The results of the MWW test indicated that total PCBs as the sum of the 43 PCB congeners of interest in the two sample populations were not significantly different ( $p > 0.05$ ). Therefore, hardhead catfish fillet samples from the two datasets can be pooled, and calculation of EPCs for total PCBs in hardhead catfish fillet from FCA 1 will be calculated from the pooled data.

#### ***Pooling Data from FCAs for Individual Tissue Types***

Nonparametric tests were run for each pair-wise combination of FCAs for each COPCH. The analyses were run separately for each tissue type: hardhead catfish fillet, crab, and clam.

#### **Hardhead Catfish Fillet**

For hardhead catfish fillet, the comparison of FCAs 1 and 3 did not support the null hypothesis that samples from these two FCAs were taken from a common distribution. Results of the MWW test indicated that mercury was the only COPCH in hardhead catfish fillet that differed between FCA 1 and FCA 3 ( $p < 0.0056$ ). No COPCHs in hardhead catfish

fillet differed between FCA 1 and FCA 2, or between FCA 2 and FCA 3. Under the conditions of non-transitivity (i.e., FCA 2 is not dissimilar to FCA 1 or FCA 3, but FCA 1 is not similar to FCA 3), additional analyses were carried out to determine whether COPCHs in hardhead catfish fillet from FCA 2 are more similar to COPCHs in tissue from FCA 1 or FCA 3 in order to determine the preferred pooling (i.e., pooling hardhead catfish fillet data from FCA 2 and FCA 1, or from FCA 2 and FCA 3).

To determine the preferred pooling of FCAs, the similarity between each pair of FCAs 1, 2, and 3 was examined using Euclidean distance as a similarity metric, calculated using data for all COPCHs. The Euclidean distance is the distance between two points and is measured by the Pythagorean formula as the square root of the sum of squares of the *X*-distance and *Y*-distance between their coordinates. Because there are nine COPCHs, each point is represented by a point with nine coordinates rather than just two. The formula for Euclidean distance is applicable to such multivariate datasets (Kachigan 1982; Legendre and Legendre 1998). The Euclidean distance is a measure of the similarity in the make-up of concentrations of all COPCHs between two samples: a smaller Euclidean distance indicates a greater similarity.

Because concentrations of different COPCHs have different magnitudes, to allow each COPCH to contribute equally to the overall measure of similarity, the concentrations of individual COPCHs need to be standardized before distance calculations are made. To standardize and scale COPCH concentrations prior to the distance calculation, first, the entire dataset (for all FCAs) was centered so that the mean for each COPCH was set at zero. Next the entire dataset (for all FCAs) was scaled so that the standard deviation for each COPCH was set to 1. Euclidean distances were then determined by calculating the distances between all pairs of hardhead catfish fillet samples in each pair of FCAs.

The findings of the analysis indicate that hardhead catfish fillet from FCAs 2 and 3 are more similar than data from FCAs 1 and 2, and therefore FCAs 2 and 3 should be pooled. A plot of the Euclidean distance for all samples between each pair of FCAs is provided in Figure C-1.

### Edible Blue Crab

For edible blue crab, the statistical comparisons supported the hypothesis that data from FCAs 2 and 3 were taken from the same distribution. Data from FCA 1 do not appear to be taken from the same distribution. Results of the MWW tests indicated that cadmium and TEQ<sub>DF</sub> in edible crab tissue differed between FCA 1 and FCA 3 ( $p < 0.0063$ ) and that mercury and PCBs in edible crab tissue differed between FCA 1 and FCA 2, and between FCA 1 and FCA 3 ( $p < 0.0063$ ). There was no difference between FCA 2 and FCA 3 for any COPCH, and the results therefore support pooling samples from FCA 2 and FCA 3.

### Edible Clam Tissue

For edible clam tissue, the statistical comparisons of FCAs 1 and 2, and FCAs 2 and 3 did not support the null hypothesis that tissue samples were taken from a common distribution. Results of the MWW tests indicated that nickel in edible clam tissue differed between FCA 1 and FCA 2 ( $p < 0.0056$ ) and that zinc differed between FCA 2 and FCA 3 ( $p < 0.0056$ ). There was no difference between FCA 1 and FCA 3 for any COPCH, and the results therefore support pooling samples from FCA 1 and FCA 3.

### ***Pooling Data for Tissue Types***

The appropriateness of pooling data for hardhead catfish fillet and edible blue crab, for which identical determinations on the FCAs that are appropriate to pool were established, was considered. As discussed further in Section 4, exposures to finfish and shellfish will be quantified separately using different ingestion rates, and individuals assumed to ingest finfish will not necessarily be assumed to ingest shellfish and vice versa. Therefore, it was determined that the hardhead catfish fillet and edible clam tissues should not be considered further for pooling.

#### **3.4.2.1.3 Summary**

The analysis resulted in the following exposure units for each tissue type to be used in the pre-TCRA exposure scenarios:

- Hardhead catfish fillet—FCA 2 and FCA 3 will be pooled (“FCA 2/3”). This pooled FCA and FCA 1 will be considered two individual exposure units with unique EPCs for each COPCH.

- Edible crab—FCA 2 and FCA 3 will be pooled (“FCA 2/3”). This pooled FCA and FCA 1 will be considered two individual exposure units with unique EPCs for each COPCH.
- Edible clam—FCA 1 and FCA 3 will be pooled (“FCA 1/3”). This pooled FCA and FCA 2 will be considered two individual exposure units with unique EPCs for each COPCH.

The exposure units defined for evaluating pre-TCRA exposure conditions are shown in Figure 9. The environmental data available for the areas are described in Table 6.

#### **3.4.2.2      *Post-TCRA***

No tissue data that are representative of post-TCRA conditions are available. As a result, it will be necessary to estimate concentrations in relevant tissue types for those COPCHs that show unacceptable risks under baseline conditions. The Technical Memorandum on Bioaccumulation Modeling (Integral 2010d) presents a suite of Site- and region-specific statistical models that can be used to predict tissue concentrations of some dioxin and furan congeners from their respective sediment concentrations, including the most potent congeners. These empirical statistical relationships provide a means to estimate tissue concentrations for a specific analyte, taking as inputs the concentrations of the same analyte in sediment, as well as ancillary information, such as total organic carbon (TOC), fines, and season.

Post-TCRA tissue concentrations will be estimated using these statistical models applied to the post-TCRA sediment data for the dioxin and furan congeners for which a statistical relationship has been established. Model inputs will be the post-TCRA sediment EPCs for each relevant exposure area, as well as associated matrix physical properties (e.g., TOC, grain size). Sediment concentrations that will be used for calculating the post-TCRA EPCs for tissue will be represented as SWACs of the exposure areas described in Section 3.5.2.

#### **3.4.3      *Exposure Units for Soils***

The determination of exposure units for soils for the BHHRA is based on an understanding of which areas are accessible for each CSM area under pre-and post-TCRA conditions. Prior to

the TCRA, the area north of I-10 could be freely accessed by fishers, recreational users, and trespassers. Fencing installed as part of the TCRA and by CWA has made much of the area inaccessible. Areas south of I-10 have historically and are currently designated for industrial activities, and fencing surrounding the area has made this area largely inaccessible to individuals. There is a potential that trespassers could access the area to a limited degree, and workers can access the area.

#### **3.4.3.1 North of I-10**

The TCRA changed the areas of the Site with which individuals may come into contact and, therefore, both pre- and post-TCRA exposure units for soil must be defined. Each is discussed below.

##### **3.4.3.1.1 Pre-TCRA**

Soil sampling locations in the area north of I-10 are fairly evenly distributed. Moreover, individuals may come into contact with all areas, rather than be isolated to a confined portion of the Site. Therefore, the soil data will be considered collectively as a single exposure unit representative of pre-TCRA conditions. All of the samples collected in the Texas Department of Transportation right-of-way are in this group.

The exposure unit defined for evaluating pre-TCRA exposure conditions is shown in Figure 10. The environmental data for the exposure unit are described in Table 6.

##### **3.4.3.1.2 Post-TCRA**

Fencing constructed as part of the TCRA limits access to some areas of the Site north of I-10. Therefore, a more limited set of soil samples will be considered to be the exposure unit representative of post-TCRA soils. Specifically, only six soil samples fall within the area of the Site that remains accessible to individuals following the TCRA; these are SJTS028, -29, -30, -and -31, and TxDOT001 and -007. These six samples represent the post-TCRA exposure unit for soils north of I-10. The uncertainty associated with the relatively small sample size for this area will be evaluated in the uncertainty evaluation completed as part of the BHHRA.

The exposure unit defined for evaluating post-TCRA soil exposure conditions is shown in Figure 11. The environmental data for the exposure unit are described in Table 6.

#### **3.4.3.2 South Impoundment Area**

The TCRA implemented in the northern portion of the Site and the fencing installed by CWA had no impact on the soils in the south impoundment area. Chemistry data available for soils in this area, combined with stations designated for sampling in February 2012, are fairly evenly distributed throughout the area that individuals are anticipated to potentially contact. No information is available to suggest that individuals who might potentially trespass or work in the south impoundment area would be confined to any specific subareas. Therefore, the soil data, including results from both Phase I and Phase II sampling events, will be considered collectively as a single exposure unit.

The exposure unit defined for evaluating exposure conditions in the south impoundment area are shown in Figure 12. The environmental data for this exposure unit are described in Table 6.

### **3.5 Exposure Point Concentrations**

This section outlines the methods that will be used to calculate EPCs for the BHHRA. The approach that will be used to calculate EPCs using available data (i.e., pre- and post-TCRA soil and sediment, and pre-TCRA tissue) is outlined in Section 3.5.1. The method for modeling post-TCRA dioxin and furan EPCs for tissue is discussed in Section 3.5.2.

#### **3.5.1 Using Medium Specific Data**

EPCs will be calculated for each COPC<sub>H</sub> in each exposure unit using the rules for handling nondetected values described in Section 3.4. The detection frequency for each of the COPC<sub>H</sub> datasets for each of the established exposure units is presented in Appendix D.

Where data are available for more than one relevant depth interval at a single location, depth-weighted concentrations will be calculated. These depth-weighted concentrations will be calculated prior to the calculation of the EPC using the following equation:

$$C_{\text{weighted}} = \frac{(C_1 \times d_1) + (C_2 \times d_2) + \dots + (C_n \times d_n)}{d_1 + d_2 + \dots + d_n} \text{ (eq. 3-1)}$$

Where:

- $C_{\text{weighted}}$  = depth-weighted concentration
- $C_{1,2,\dots,n}$  = concentration for depth increment analyzed.
- $d_{1,2,\dots,n}$  = fraction of the total depth represented by the depth increment.

EPCs will be calculated using the software R for Windows version 2.9.0 (R Development Core Team 2008). CT and RM EPCs will be generated.<sup>8</sup> The statistics selected will be appropriate to the data as follows:

- For normal data distributions, the arithmetic mean will be chosen as the CT EPC. The lesser of the 95UCL based on a Gaussian data distribution and the maximum value will be selected for the RM EPC.
- For lognormal distributions, the geometric mean will be chosen as the CT EPC. The lesser of the 95UCL, based on a lognormal data distribution, and the maximum value for the dataset will be selected for the RM EPC.
- For other or unknown data distributions (i.e., those distributions that are not normal and cannot be transformed to a log-normal distribution), the arithmetic mean will be chosen as the CT EPC. The lesser of the 95UCL, based on an unknown distribution, and the maximum value for the dataset will be selected for the RM EPC.

The distribution of each dataset and the recommended EPCs and their bases will be included in the BHHRA.

### 3.5.2 **Post-TCRA Tissue**

For those dioxin and furan congeners for which significant statistical relationships between sediment and tissue are available, the best-fit regression models established (Integral 2011d) will be used to predict post-TCRA concentrations of those congeners in tissues. SWACs for

<sup>8</sup>A discussion of the purposes of CTE and RME estimates in risk assessment is provided in Section 4 in the broader context of defining the full range of assumptions used to estimate exposure.

surface sediments for each exposure unit will be used as inputs for the models. The modeled tissue concentrations for individual congeners will be used along with congener-specific TEF,<sup>9</sup> to calculate post-TCRA TEQ<sub>DF</sub> concentrations. To explore the impact of uncertainties associated with the regression models, the range of error in the tissue concentrations that are predicted by each regression at a given sediment concentration will be considered in the exposure estimate, and a range of EPCs for post-TCRA tissue will be presented.

While statistically significant regression models for all 17 dioxin-like congeners are not available for each of the tissue types, there are models for the congeners with the highest concentrations in tissue, and the highest toxicity relative to 2,3,7,8-TCDD (see Appendix E, Table E-1 for an analysis of the mixture of congeners in tissue). Nevertheless, all 17 dioxin like congeners will not be included in the estimated post-TCRA TEQ<sub>DF</sub> for any of the tissue types, and resulting modeled TEQ<sub>DF</sub> concentrations will therefore be biased low. The uncertainty associated with this approach will be addressed by using regression statistics calculated on the basis of TEQ<sub>DF</sub> for both sediment and tissue, as provided in the final PSCR at the request of USEPA.

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<sup>9</sup> TEFs are shown in Table 4. Methods for calculating TEQ<sub>DF</sub> are described in Section 3.3 and the project Data Management Plan.

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## 4 EXPOSURE EQUATIONS AND PARAMETERS

To quantify exposure, human intake levels resulting from contact with COPCs are estimated using exposure algorithms. The algorithms quantify each type of exposure as an intake, defined as the mass of a chemical contacted per unit body weight per unit time. As is customary in the field of health risk assessment, intake will be expressed in one of two forms, depending on the type of risk that is being assessed. Average daily dose (ADD) and lifetime average daily dose (LADD) will be used as measures of intake for characterizing noncarcinogenic<sup>10</sup> and carcinogenic effects, respectively. The difference between these two dose metrics is the time period over which the exposure is averaged, with the averaging time equivalent to the exposure duration for the ADD and the averaging time equivalent to a lifetime for the LADD.

USEPA (1993) guidance for Superfund recommends that two types of exposure estimates be calculated. The reasonable maximum exposure (RME) is defined as the highest exposure that could reasonably be expected to occur for a given exposure pathway and scenario at a site. The RME is intended to account for uncertainty in the contaminant concentration, and for variability and uncertainty in exposure parameters. USEPA also recommends that the central tendency estimate (CTE), or average estimate of exposure, be presented in the risk assessment. Both RME and CTE estimates will be calculated for the BHHRA.

The variables in the exposure algorithms are called exposure factors. The value selected for each factor represents a specific assumption or set of assumptions, and depends on the receptor population being evaluated. Some of these are site-specific and can be measured for the Site, and others are assumptions taken from literature or USEPA sources. Consistent with the RI/FS Work Plan (Section 6.3.3.3) (Anchor QEA and Integral 2010), several regulatory agency and literature sources have been considered when deriving parameter values, including the following:

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<sup>10</sup> Most carcinogenic compounds are evaluated using a LADD. However, as described in the Toxicological and Epidemiological Studies Memorandum (Integral 2012), the carcinogenicity of some compounds depends on whether the level of exposure reaches a threshold dose. To characterize risk for these carcinogens, the exposure metric will be presented as an ADD.

- Risk Assessment Guidance for Superfund (RAGS) Volume I Part A (USEPA 1989)
- RAGS Volume I Part B—Development of Risk-Based Preliminary Remediation Goals (USEPA 1991a)
- RAGS Volume I Part C—Risk Evaluation of Remedial Alternatives (USEPA 1991b)
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (USEPA 1991c)
- Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA 1993)
- Soil Screening Guidance: User's Guide (USEPA 1996)
- Exposure Factors Handbook (USEPA 2011b)<sup>11</sup>
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002c)
- RAGS Volume I Part E—Supplemental Guidance for Dermal Risk Assessment (USEPA 2004)
- Texas Administrative Code sections containing exposure equations and parameters (TAC 350.74-75)

In addition, regionally relevant information on fish and shellfish consumption was considered (Alcoa 1998).

The remainder of Section 4 presents the specific equations, parameters, and assumptions that will be used to quantify exposure in the BHHRA. First, the exposure equations and a general discussion of the parameters used within them are presented. Next, the way in which exposures will be characterized for each receptor group is presented. This presentation includes a discussion of the exposure scenarios that will be characterized including the manner in which exposures from individual pathways will be summed, and the parameters and assumptions that will be used for each individual pathway. Finally, chemical-specific parameters are discussed.

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<sup>11</sup> The final 2011 Exposure Factors Handbook was released in September 2011, superseding the 2007 Exposure Factors Handbook and the 2008 Child-Specific Exposure Factors Handbook.

The specific scenarios for which intake will be quantitatively evaluated are presented in Table 7. The full sets of exposure factor assumptions to be used in the BHHRA along with the pathway-specific equations for calculating intake are presented in Tables 8 through 12. Tables 13 and 14 present summaries of the assumptions to be applied in the BHHRA for assessing exposure pathways in the area north of I-10 and aquatic environment, and the south impoundment area, respectively. Table 15 presents the chemical-specific parameters to be used in the BHHRA.

#### 4.1 Introduction to Exposure Equations and Parameters

The specific equation and parameters used to estimate intake varies, depending on the exposure route being evaluated. Three types of exposures will be evaluated in the BHHRA: 1) ingestion of sediment and/or soil, 2) dermal absorption of sediment and/or soil, and 3) ingestion of fish and/or shellfish. The equations that will be used to calculate these exposures are presented below. A general explanation of the exposure parameters that are included in the equations follows.

##### Equation 4-1. Intake via Ingestion of Soil and/or Sediment

*Relevant Receptor Groups: fishers, recreational visitors, trespassers, workers*

$$I_{\text{soil-sed}} = \frac{[(C_{\text{soil}} \times IR_{\text{soil}} \times F_{\text{soil}}) + (C_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}})] \times RBA_{\text{soil-sed}} \times FI_{\text{soil-sed}} \times EF_{\text{soil-sed}} \times ED \times CF_1}{BW \times AT} \quad (\text{eq. 4-1})$$

Where:

$I_{\text{soil-sed}}$	=	intake, the mass of a chemical contacted in soil and sediment by the receptor per unit body weight per unit time (mg/kg-day)
$C_{\text{soil}}$	=	chemical concentration in soil contacted over the exposure period (i.e., EPC for soil) (mg/kg)
$IR_{\text{soil}}$	=	soil ingestion rate (mg/day)
$F_{\text{soil}}$	=	fraction of total ingestion that is soil (% as fraction)
$C_{\text{sed}}$	=	chemical concentration in sediment contacted over the exposure period (i.e., EPC for sediment) (mg/kg)
$IR_{\text{sed}}$	=	sediment ingestion rate (mg/day)
$F_{\text{sed}}$	=	fraction of total ingestion that is sediment (% as fraction)

$RBA_{ss}$	=	relative bioavailability adjustment for soil and sediment (% as fraction)
$FI_{soil-sed}$	=	fraction of total daily soil/sediment intake that is site-related (% as fraction)
$EF_{soil-sed}$	=	exposure frequency (days/year)
$ED$	=	exposure duration (years)
$CF_1$	=	conversion factor ( $1 \times 10^{-6}$ kg/mg)
$BW$	=	body weight (kg)
$AT$	=	averaging time (days)

**Equations 4-2 and 4-3. Dermal Absorbed Dose via Contact with Soil and Sediment**  
*Relevant Receptor Groups: fishers, recreational visitors, trespassers, workers*

$$DAD_{soil-sed} = \frac{DA_{event} \times SA \times EF_{soil-sed} \times FI_{soil-sed} \times ED \times EV}{BW \times AT} \quad (\text{eq. 4-2})$$

Where:

$DAD_{soil-sed}$	=	dermal absorbed dose from soil and sediment (mg/kg-day)
$DA_{event}$	=	absorbed dose per event (mg/cm <sup>2</sup> )
$SA$	=	skin surface area available for contact (cm <sup>2</sup> )
$EV$	=	event frequency (day <sup>-1</sup> )

And,

$$DA_{event} = [(C_{soil} \times AF_{soil} \times F_{soil}) + (C_{sed} \times AF_{sed} \times F_{sed})] \times ABS_d \times CF_1 \quad (\text{eq. 4-3})$$

Where:

$AF_{soil}$	=	adherence factor for soil (mg/cm <sup>2</sup> )
$AF_{sed}$	=	adherence factor for sediment (mg/cm <sup>2</sup> )
$ABS_d$	=	dermal absorption factor for soil/sediment (% as fraction)

**Equation 4-4. Intake via Ingestion of Fish and Shellfish***Relevant Receptor Groups: fishers*

$$I_{\text{tissue}} = \frac{C_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times RBA_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2}{BW \times AT} \quad (\text{eq. 4-4})^{12}$$

Where:

$I_{\text{tissue}}$	=	intake, the mass of a chemical contacted in fish or shellfish tissue by the receptor per unit body weight per unit time (mg/kg-day)
$C_{\text{tissue}}$	=	chemical concentration in fish or shellfish tissue contacted over the exposure period (i.e., EPC for fish or shellfish) (mg/kg)
LOSS	=	chemical reduction due to preparation and cooking (% as fraction)
$IR_{\text{tissue}}$	=	fish or shellfish ingestion rate (g/day)
$RBA_{\text{tissue}}$	=	relative bioavailability adjustment for tissue (% as fraction)
$FI_{\text{tissue}}$	=	fraction of total fish or shellfish intake that is site-related (% as fraction).
$EF_{\text{tissue}}$	=	exposure frequency for fish or shellfish consumption (days/year)
$CF_2$	=	conversion factor ( $1 \times 10^{-3}$ kg/g)

A general description of the exposure parameters included in the preceding equations 4-1 through 4-4 is presented below. General parameters used in all equations are discussed first, followed by pathway-specific parameters. The specific values that will be used for each parameter for Site receptors are presented in Section 4.2.

**Body Weight (BW)**

USEPA (2004) recommends that mean age specific body weights be assumed for both CTE and RME scenarios. USEPA's 2011 Exposure Factors Handbook (USEPA 2011b) provides mean values for body weight by age, based on data collected from the 1999–2006, National Health and Nutrition Examination Survey (NHANES). Age-specific mean body weights from this source have been adopted for the BHHRA.

<sup>12</sup> The equation presented here uses the term tissue generically to present parameters for finfish and shellfish. Intake of finfish and shellfish will be estimated separately for the BHHRA.

**Exposure Frequency (EF)**

The exposure frequency is the average number of days per year that an individual is exposed at a site. While USEPA guidance recommends exposure frequencies for residential and worker populations (350 days/year and 225 to 250 days/ year for various types of workers, respectively) (USEPA 2002c), they do not provide recommendations for this parameter for recreational or trespasser scenarios. USEPA's default factors and best professional judgment were used to select exposure frequencies for the BHHRA.

**Exposure Duration (ED)**

The exposure duration is the number of years over which an exposure occurs. USEPA (2011b) provides standard default assumptions for residence time based on studies of occupational mobility. Thirty-three years and 12 years are recommended as RME and CTE estimates, respectively. USEPA (2002c) recommends an exposure duration of 25 years for commercial/industrial workers based on the Bureau of Labor Statistics 95<sup>th</sup> percentile value for job tenure for men in the manufacturing sector. These default values and best professional judgment were used to select exposure durations for the BHHRA.

**Averaging Time (AT)**

The averaging time selected depends on the toxic endpoint (cancer or noncancer) being assessed. For noncarcinogens, the averaging time equals the exposure duration (e.g., for an exposure duration of 6 years, the averaging time is 2,190 days). For carcinogens, the averaging time is equal to a lifetime (i.e., 78 years, or 28,470 days) (USEPA 1989, 2011b). This distinction relates to the manner in which toxicity criteria are generally developed for non-carcinogens and carcinogens. Generally, the toxicity of carcinogens is described using criteria that assume a linear dose response, where any incremental dose results in an increased risk of cancer (i.e., no threshold is assumed). However, in some cases, the toxicity of a carcinogen is described using a criterion that assumes a threshold dose of the substance is required in order for an adverse effect to be elicited. When the toxicity criterion for a carcinogen assumes a threshold dose, an averaging time equal to the exposure duration will be used.

**Soil and Sediment Ingestion Rates ( $IR_{soil}$ ,  $IR_{sed}$ )**

USEPA (2011b) provides recommendations for soil ingestion rates for a variety of age groups. USEPA guidance does not provide default ingestion rates for sediment, and there are no studies available in the peer-reviewed literature to provide the basis for an estimate. In the absence of data on specific ingestion rates for sediment, soil ingestion rates from USEPA will be applied to both soil and sediment media.

USEPA (2011b) recommends an ingestion rate of 20 mg/day for typical adults. Based on the assumption that workers may be involved in contact-intensive activities, USEPA (2002c) suggests a higher soil ingestion rate of 100 mg/day for outdoor workers. Young children may ingest larger amounts of soil daily because of greater hand-to-mouth activity. USEPA (2011b) recommends an ingestion rate of 50 mg/day as the central tendency rate for individuals ages 1 to <21 years. In addition, for children ages 3 to <6 years, USEPA recommends an upper-bound estimate of 200 mg/day.

Recommended central tendency rates, and when available, upper-bound estimates, were adopted for the BHHRA for CTE and RME estimates, respectively. Following recommendations from USEPA (2011b), weighted average rates were calculated in order to characterize ingestion rates for different age groups across a period of time that encompasses more than one age group.

**Surface Area (SA)**

The surface area factor describes the amount of exposed skin that may come into contact with soil or sediment. USEPA (2011b) provides recommended surface areas for individual body parts for a range of age groups based on data collected from the 1999–2006 NHANES. USEPA (2004) recommends adopting mean surface areas for both CTE and RME scenarios. Age specific surface areas for men and women combined from USEPA (2011b) were selected for the BHHRA.

**Adherence Factor for Soil/Sediment**

The adherence factor describes the mass of soil or sediment that adheres to the skin per unit of surface area. Adherence is influenced by the properties of the soil or sediment (e.g.,

moisture content), and also varies considerably across different parts of the body and with different activities (USEPA 2004).

USEPA (2004, 2011b) provides adherence factors for a variety of activities including those that describe residential, recreational, and occupational exposures. The majority of the data are available for the soil matrix; however, data are available from one study that measured adherence of sediment to skin in children.

Adherence factors were selected from data provided by USEPA to match the receptor of interest, its activity, and the soil/sediment matrix as closely as possible. Sediment data available for children were used for all ages given the lack of available data for other age groups.

Following USEPA recommendations, weighted adherence factors were calculated for each age group on the basis of relative surface areas of exposed body parts and body-part-specific adherence factors presented by USEPA. The same assumptions were selected for both CTE and RME scenarios.

### **Event Frequency**

“Event frequency” refers to the number of times per day an event occurs on any exposure day. For dermal contact with both soil and sediment, the event frequency is assumed to be 1.

### **Fractions of Total Pathway Exposure to Soil and to Sediment ( $F_{\text{soil}}$ , $F_{\text{sediment}}$ )**

These factors apportion the direct contact individuals have at the Site between soil and sediment. The soil and sediment ingestion rates discussed above are developed as total daily intake rates. To assume that an individual is exposed to both soil and sediment, and use the default daily ingestion rates to evaluate both, would result in large overestimates of potential exposure. Instead, it is more appropriate to assume that this total daily intake will be from a combination of soils and sediments contacted during the day as appropriate for the scenario.

In addition, the adherence factors described above will differ between soil and sediment. To estimate exposure, it is therefore necessary to describe the portion of the dermal exposure

pathway that will be attributable to soil and sediment. Professional judgment about likely scenario-specific activities was used to assign these fractions.

**Fraction of Total Daily Intake from Soil/Sediment That Is Site-Related ( $FI_{\text{soil-sediment}}$ )**

The intent of this fractional intake term is to provide a modifying factor to account for situations when the total daily intake rate (e.g., the fraction of sediment multiplied by the sediment ingestion rate and the fraction of soil multiplied by the soil ingestion rate) for an individual would not be derived exclusively from the Site. Assuming a fractional intake of 1.0 implies that all sediment and soil incidentally ingested and absorbed via dermal contact during a daily exposure originated from the Site. In instances where individuals spend only a few hours at the Site, and also participate in other activities away from the Site where they will be exposed to sediment or soil, a fractional intake of less than 1.0 will be more appropriate for estimating exposure. Information about the Site was considered when determining the value for this factor for each receptor.

**Ingestion Rates for Fish and Shellfish**

Ingestion rates of self-caught fish and shellfish tissue can vary dramatically depending upon location/region, type of fishing, and species of fish caught. USEPA has developed a number of default consumption rates for fish and shellfish consumption based on national, regional, and site-related surveys. However, because of the variable nature of consumption patterns, USEPA (2011b) recommends using Site- or region-specific information when such data exist and are of good quality. Both default consumption rates and regional data on consumption were reviewed to select the most appropriate values for the BHHRA.

**Fraction of Total Fish or Shellfish Intake That Is Site-Related**

The fractional intake term represents the fraction of total fish and shellfish consumption that is specifically harvested from the Site. A fractional intake of 1.0 reflects an assumption that 100 percent of the fish and shellfish consumed is harvested at the Site. The fractional term will be dependent on a number of Site-specific parameters including the accessibility and size of the Site and the number of alternative fishing locations surrounding the Site. Information about the Site was considered when determining this factor.

### **Other Parameters**

Chemical specific parameters shown in equations 4-1 through 4-4 including EPCs, relative bioavailability adjustment (RBA) factors, dermal absorption factors, and factors that account for chemical loss due to preparation and cooking are discussed elsewhere. Specifically, methods for calculating EPCs for sediments, tissue, and soils are presented in Section 3.5. The remaining chemical specific parameters are presented in Section 4.3.

## **4.2 Area-Specific Exposure Parameters and Assumptions**

This section provides a detailed description of the way that exposure will be estimated in the BHHRA. It describes each receptor group, the scenarios for which exposure will be evaluated, and the exposure factors that will be used to calculate intake. The exposures to be evaluated in the area north of I-10 and aquatic environment and the south impoundment area are discussed in Sections 4.2.1 and 4.2.2, respectively.

### **4.2.1 Area North of I-10 and Aquatic Environment**

This section details the specific exposures that will be characterized and the exposure assumptions that will be adopted in the BHHRA for the north impoundment area.

#### **4.2.1.1 Receptor Groups and Exposure Scenarios**

Two types of fishers are outlined as human receptors in the CSM for this area: a recreational fisher and a subsistence fisher. The recreational fisher is assumed to be an individual who periodically fishes on the Site. USEPA (2011b) defines subsistence fish consumers as those individuals who rely on sport-caught fish as a source of food and, as a result, eat more fish than the general population.<sup>13</sup> Recreational visitors have also been identified as a receptor group with potential exposures for this area. Recreational visitors may walk around, or spend time recreating throughout the Site.

Fishers and recreational visitors may come into contact with soils in the area north of I-10 and/or sediments throughout the areas of the Site in which the water is shallow enough to

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<sup>13</sup> Because these individuals are a hypothetical subpopulation of the fishers who may use the Site and their definition is based on higher than typical consumption rates, no CTE evaluation will be conducted for the subsistence fisher scenario. Only an RME evaluation will be completed for this receptor group.

allow for wading. Given that the primary activity of the fisher occurs at the shoreline, it will be assumed that their exposures to soils will be inconsequential compared with their potential exposures to shoreline and near-shoreline sediment. It is assumed that recreational visitors may have contact with both near-shoreline sediment and soil. Potentially complete exposure pathways via these matrices include direct ingestion and dermal absorption.

Both groups of fishers may ingest fish and/or shellfish caught at the Site. Information regarding fishing activities and consumption patterns at the Site is not available. In the absence of specific information on diet, exposures will be estimated separately under three scenarios: one scenario will consider finfish ingestion only, a second will consider crab ingestion only, and a third will consider clam ingestion only. Focusing the risk assessment on single-tissue type exposures is conservative because it will identify and quantify exposure to the tissue type that results in the highest potential for exposure. In estimating cumulative exposure, exposure from direct contact pathways (ingestion and dermal absorption of soil and/or sediment) will be summed with that from each tissue ingestion scenario separately. The result will be three different cumulative intake estimates. The impact of this assumption will be evaluated in the uncertainty evaluation completed for the BHHRA. Exposure via a mixed diet (i.e., where the total diet coming from fish and shellfish is assumed to be composed of some proportion of finfish, crab, and clam) will be considered as part of this uncertainty evaluation.

The scenarios for which exposure will be evaluated in the BHHRA are described in Table 7. The scenarios reflect the complete pathways and the exposure units established in Section 3.4. They are:

- Fishers—direct contact (i.e., ingestion of and dermal absorption) with sediments at individual exposure units defined for sediments, summed with ingestion of tissue from geographically corresponding exposure units for tissue. Three tissue ingestion scenarios will be considered: 1) ingestion of finfish from the Site, 2) ingestion of edible crab from the Site, and 3) ingestion of edible clam from the Site. Exposures to younger children (ages 1 to < 7), older children (ages 7 to < 18), and adults will be considered.
- Recreational Visitors—direct contact (i.e., ingestion of and dermal contact) with sediments at individual exposure units defined for sediments, summed with direct

contact at the single exposure unit defined for soil. Exposures to younger children (ages 1 to < 7), older children (ages 7 to < 18), and adults will be considered.

These scenarios will conservatively assume that each fisher and recreational visitor spends all of his or her time at a single beach area (i.e., A, B/C, D, or E). For the fisher, it will be further assumed that all of the tissue that is consumed is harvested from the FCA that borders that beach area. Although it is anticipated that fishers and recreational visitors would likely visit more than a single beach area over the chronic exposure duration being evaluated, estimating exposures at each exposure unit separately allows for incremental exposures that potentially occur in statistically different units to be evaluated, providing a stronger basis for risk management decisions. The impact of this assumption will be discussed in the uncertainty analysis.

The entire Site is accessible under pre-TCRA conditions but fencing constructed as part of the TCRA and by CWA currently limits access to Beach Areas B/C, D, and E. These limitations to Site access will be captured in the post-TCRA exposure scenarios described.

#### **4.2.1.2 Exposure Assumptions**

Exposure assumptions for the recreational fisher, subsistence fisher, and recreational visitor are summarized in Tables 8, 9, and 10, respectively, and are discussed below.

##### **4.2.1.2.1 Exposure Parameters Common to All Pathways**

Given the lack of Site-specific information on fishing and recreational behaviors, exposure durations were conservatively based upon standard default assumptions for used for residents. For fishers and recreational visitors, the RME duration will be assumed to be 33 years, and the CTE duration will be assumed to be 12 years (USEPA 2011b).

Children or adolescents may accompany adults who are fishing or recreating at the Site. Default exposure assumptions vary with age (e.g., higher ingestion rates and lower body weights for young children) and young children have higher exposures relative to other age groups. Therefore, for the RME scenarios for the fishers and recreational visitors, it will be

assumed that a portion of the total exposure occurs at these younger life stages.<sup>14</sup> This assumption results in an upper bound RME scenario in which the calculated exposure for any alternative age group over the same chronic duration would be less. Because of the location of the site, the individuals most likely to use the Site are adults. Therefore, for the CTE analysis, only adult exposures will be evaluated.

Differences in activity and intake parameters have been characterized for younger children, older children, and adults. Therefore, exposure parameters are presented separately for young children (ages 1 to < 7), older children (ages 7 to < 18), and adults (ages 18 and older).<sup>15</sup>

Body weights of 19, 50, and 80 kg were selected for the young child, older child, and adult age groups, respectively.

#### 4.2.1.2.2 Direct Contact Parameters

The majority of activity by the fisher is expected to occur along the water's edge so that substantial exposure to Site-related soil is not likely. Therefore, for the fishing scenarios, the fraction of total intake that is attributed to Site-related soils will be assumed to be zero, while the fraction of total daily intake from sediment will be assumed to be 1.0 (100 percent). It is envisioned that the recreational visitor spends equal amounts of time in contact with soils and sediments. Therefore, the fraction of pathway exposure to soils and the fraction of pathway exposure to sediments are both assumed to be 0.5. The uncertainties associated with these assumptions will be explored as part of the uncertainty evaluation that will be completed for the BHHRA.

Based on USEPA's (2011b) recommended ingestion rates for soil, soil and sediment ingestion rates of 20 mg/day will be adopted for adults. This rate will be used to evaluate both CTE

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<sup>14</sup> The earliest age that exposure is assumed to occur via the potentially complete pathways for this receptor is 1 year.

<sup>15</sup> For scenarios where multiple age groups are outlined, ADDs will be calculated for each age group individually. LADD will be calculated as a sum of intakes across all age groups.

and RME estimates. An ingestion rate of 50 mg/day will be adopted for older children. For younger children, a weighted average rate of 125 mg/day will be used.<sup>16</sup>

For the skin surface area parameter, based on the assumption that an individual's hands, forearms, lower legs, and feet may come into contact with soil and/or sediment, surface areas of 6,080 and 4,270 cm<sup>2</sup>, will be used for the older child and adult, respectively (USEPA 2011b). For young children playing in the soil and/or sediment, it is assumed that the entire surface area of the leg may be in contact with sediments in addition to the hands, forearms, and feet. Based on this assumption, the surface area of 3,280 cm<sup>2</sup> will be used (USEPA 2011b).

Weighted sediment adherence factors of 3.6, 5.1, and 4.9 mg/cm<sup>2</sup> for young children, older children, and adults, respectively, were derived based on a study of children playing in sediment (USEPA 2011b). Using data which describes the adherence of soils to skin in adults participating in a variety of activities (USEPA 2011b), a soil adherence factor of 0.07 mg/cm<sup>2</sup> was derived for older children and adults. Data from a study conducted in children exposed to soil were used to derive a soil adherence factor of 0.09 mg/cm<sup>2</sup> for young children (USEPA 2011b).

The exposure frequencies for direct contact pathways can be based on estimates of the number of trips to the site each year. The derivation of the assumption to be used for this parameter differs for recreational fishers, subsistence fishers, and recreational visitors.

According to the 2006 survey of Texas anglers conducted by the U.S. Fish and Wildlife Service (USFWS), the mean number of days spent fishing marine waters by Texas residents was 13 days/year (USFWS 2008). While the USFWS data presentation does not provide the full range of values, it is reasonable to assume that more avid anglers may fish with a higher frequency than the average. A survey conducted of Maine's freshwater anglers (Ebert et al. 1993), for which the average frequency of fishing trips was 24 trips per year, found that the 95th percentile frequency was 70 trips per year (unpublished data), or nearly triple the mean

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<sup>16</sup> Rates for the older child and young child are for the RME scenario. There is no child component considered in the CTE scenario for the recreational fisher and visitor. No CTE evaluation will be completed for the subsistence fisher.

frequency. If it is assumed that more avid Texas marine anglers also fish at three times the average rate, this would result in an upper bound trip frequency of 39 trips per year. Based on this information, CTE and RME frequencies for the recreational fisher will be 13 and 39 days/year, respectively.

No quantitative data exist with which to quantify the number of trips (or exposure frequency) for hypothetical subsistence fishers. It is reasonably anticipated that subsistence fishers may participate in fishing activities more often than recreational fishers; however, it is not likely that they would fish the same location more than an average of 2 days per week on average, every week of the year, over the entire exposure duration of 33 years. In addition it is conservatively assumed that 100 percent of the sediment ingested or contacted during the day on which fishing occurs is derived from the Site. This is not likely to be the case because these individuals will spend a portion of those days elsewhere and thus a fraction of the soil/sediment contacted will not be Site-related. Therefore, based on best professional judgment, a value of 104 days per year, which is an average of 2 days per week throughout the year, was selected as the exposure frequency for the subsistence fisher.

In the absence of data concerning recreational use of the Site, RME and CTE frequencies of 104 and 52 days per year, respectively, will be assumed for recreational visitors. These are based on assumed average frequencies of 2 days per week and 1 day per week throughout the course of the year, respectively.

It is not anticipated that a fisher's or visitor's direct contact with soils/sediments would typically be limited to the Site. These individuals would likely not spend the entirety of each day that they fish at the Site; rather they might spend only a few hours and also participate in other activities away from the Site where they will be exposed to sediment or soils. However, no site specific information is available with which to estimate the fraction of total daily soil/sediment intake that is Site-related. Based on best professional judgment, a conservative fractional intake of 1.0 will be adopted for the RME. A fractional intake of 0.5 will be adopted for the CTE.

#### 4.2.1.2.3 Fish and Shellfish Intake Parameters

Consumption of fish and shellfish is defined as a potentially complete pathway for fishers only. Ingestion rates and the fraction of tissue intake that is Site-related are discussed below for these two receptors.

##### ***Ingestion Rates***

###### **Recreational Fisher**

USEPA's (2011b) Exposure Factors Handbook recommends age-specific mean and 95th percentile rates of consumption of recreationally caught marine fish for anglers who fish the Gulf Coast. For adults, the recommended mean and 95th percentile values are 7.2 and 26 g/day, respectively. These recommendations are based on the results of a survey of coastal areas throughout the continental United States conducted by the National Marine Fisheries Service (NMFS 1993). USEPA (2011b) segregated the NMFS (1993) data by region in developing these region-specific rates.

To derive consumption rates, NMFS (1993) adjusted the total mass of fish caught by a very conservative edible fraction of 50 percent to calculate the edible mass of fish consumed. They then used an average family size of 2.5 individuals to address sharing of the consumed fish within the household and derive daily rates on a per-person basis.

All coastal states in the U.S. were included in the survey with the exception of Texas and Washington. While it is likely that the rates derived for Gulf waters in Texas would be similar to rates derived for other Gulf states, the lack of Texas-specific data contributes some uncertainty about the appropriateness of applying these data to Texas anglers. In addition, the survey made assumptions about family size based on census data, rather than angler-specific data, in order to address sharing of the fish within the household. This is an assumption that also introduces some uncertainty into the rates.

A Texas-specific study of fishing activity and consumption was conducted in Lavaca Bay (Alcoa 1998). Lavaca Bay, which covers roughly 40,000 acres, is part of the larger Matagorda Bay system. This system is similar in size to Galveston Bay and is situated further south along the Texas coastline. The demographics in the counties surrounding the two bays are

similar (2010 Census data for Calhoun, Chambers, Galveston, Harris, Jackson, and Victoria counties).<sup>17</sup>

Initially, four populations were identified as having potential for exposure to chemical constituents through the ingestion of Lavaca Bay fish. These included the following:

- Subsistence populations
- Non-anglers within the general population who consumed commercially caught fish from Lavaca Bay
- Recreational anglers
- Commercial shrimpers.

As part of its Health Consultation for the Alcoa Site, TDH (1996) evaluated the fishing habits of Vietnamese shrimpers who fished out of Lavaca Bay because there was concern that they might represent a potential subsistence population. TDH conducted a door-to-door survey of this population and concluded that they were not at risk because their shrimping activities generally occurred outside of Lavaca Bay. The findings indicated that no true subsistence fishing activity was occurring within Lavaca Bay.

To address the potential exposure of recreational anglers, Alcoa (1998) conducted two surveys. A general population study was first conducted to help focus the angler survey effort. Then, the Texas Saltwater Angler survey was conducted to collect the necessary data about consumption rates, fraction ingested from the contaminated source, and the species composition of the fish consumed. This survey was conducted in 1994 during the month of November, which was reported to be the month of highest fishing activity in the bay (Alcoa 1998). It included an initial mailing of survey materials to anglers in the three counties surrounding Lavaca Bay, followed by telephone interviews with those anglers. It was specifically conducted to support a risk assessment for the Alcoa Point Comfort/Lavaca Bay Superfund Site. Nearly 2,000 anglers participated in that study.

Alcoa (1998) reported the following mean and 95UCL consumption rates for finfish by age category<sup>18</sup>:

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<sup>17</sup> <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>

- Adult men: mean – 24.8 g/day; 95UCL – 27.7 g/day
- Adult women: mean – 17.9 g/day; 95UCL – 19.7 g/day
- Women of childbearing age: mean – 18.8 g/day; 95UCL – 22.1 g/day
- Youths: mean – 15.6 g/day; 95UCL – 17.8 g/day
- Small children: mean – 11.4 g/day; 95UCL – 14.2 g/day.

The study reported the following shellfish consumption rates by age category:

- Adult men: mean – 1.2 g/day; 95UCL – 1.6 g/day
- Adult women: mean – 0.8 g/day; 95UCL – 1.1 g/day
- Women of childbearing age: mean – 0.9 g/day; 95UCL – 1.2 g/day
- Youths: mean – 0.7 g/day; 95UCL – 1.0 g/day
- Small children: mean – 0.4 g/day; 95UCL – 0.6 g/day.

The upper bound values are similar to but slightly higher than the rates recommended by USEPA (2011b) for the Gulf Coast region; however, the mean rates are quite a bit higher than USEPA's recommended means.

These ingestion rates for finfish and shellfish will be adopted for the recreational fisher for the BHHRA. They were selected because they are Texas-specific and represent consumption from a fishery that is similar to the fishery associated with the Site. Mean rates will be used for the CTE analysis, while the 95UCL rates will be used for the RME analysis. The average of rates for men and women will be assumed for the adult ingestion rates. The rates provided for youths in the study will be adopted for the older child while the rates provided for small children will be used for the young child.

#### Subsistence Fisher

USEPA does not provide recommended fish consumption rates for subsistence fishers, and only discusses subsistence in terms of localized Native American and Alaskan native subsistence populations. However, it is possible that there is a subset of fishers who consume fish at the upper end of the fish consumption rate distribution.

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<sup>18</sup> The study did not specify the ages of individuals considered in each of the age categories.

The Lavaca Bay study did not identify a true subsistence population, in terms of socioeconomic demographics. However, it did report upper bound rates based on the survey data collected. Using a ranking approach, Alcoa (1998) presented 90<sup>th</sup> percentile fish consumption rates for the anglers surveyed and 95<sup>th</sup> percentile shellfish consumption rates. (The 95<sup>th</sup> percentile rates were reported for shellfish because the overall levels of consumption were very low and thus the 90<sup>th</sup> percentile of the distribution was also very low.)

The study reported the following 90<sup>th</sup> percentile consumption rates for finfish:

- Adult men: 68.1 g/day
- Adult women: 47.8 g/day
- Youths: 45.4 g/day
- Small children: 30.3 g/day.

The study reported the following 95<sup>th</sup> percentile consumption rates for shellfish:

- Adult men: 5.1 g/day
- Adult women: 2.4 g/day
- Youths: 4.5 g/day
- Small children: 2.0 g/day.

These rates were selected for the finfish and shellfish ingestion rates to be used in evaluating exposures to subsistence fishers for the BHHRA. The average of rates for men and women will be assumed for the adult ingestion rates. The rates provided for youths in the study will be adopted for the older child while the rates provided for small children will be used for the young child.

### ***Fraction of Tissue Intake That Is Site-Related***

#### **Recreational Fisher**

Given the relatively small spatial extent of the Site compared with the size of the Galveston Bay fishery, it is unlikely that 100 percent of the fish consumed over the 33 year exposure duration assumed for the RME will be harvested from the Site. This is demonstrated by survey data for Lavaca Bay. Of interest to the risk assessors who conducted the survey was

information about the locations where fish were harvested so that it would be possible to determine the fraction of fish taken from the 1,500 acre subarea (indicated as the closure area), the fraction taken from other portions of Lavaca Bay, and the fraction taken from other areas outside of Lavaca Bay.

Similar to conditions at Lavaca Bay, the waters associated with the SJRWP Site represent a very small fraction of the Galveston Bay fishery. Also like Lavaca Bay, there are many other locations around Galveston Bay that can be used for fishing. Thus, the fraction of fish actually consumed from waters on the Site is likely to be limited.

The survey conducted by Alcoa (1998) at Lavaca Bay segregated the consumption data by the areas fished; specifically, the closure area, other portions of Lavaca Bay, and areas outside of Lavaca Bay. The study reported averages of 0.6 and 8.5 percent of finfish consumed were collected from the 1,500 acre closure area and Lavaca Bay, respectively. It reported 95UCLs of 0.9 and 9.7 percent of finfish consumed were collected from the closure area and Lavaca Bay, respectively. The majority of finfish consumed (i.e., approximately 90 percent) were obtained from areas outside of Lavaca Bay. The study reported averages of 0 and 0.1 percent of shellfish consumed were from the closure area and Lavaca Bay, respectively. 95UCLs of 0 and 0.2 percent of shellfish consumed were collected from the closure area and Lavaca Bay respectively. More than 99 percent of shellfish consumed were from areas outside of Lavaca Bay.

The fraction of total fish consumed from Lavaca Bay is a reasonable estimate of fish and shellfish consumption from a single fishing area, and will be used to estimate the fraction of total tissue consumed by recreational anglers that is derived from the Site. Both the mean and the 95UCL for fractional intake of finfish in the closure area within Lavaca Bay are less than 10 percent, and the fraction of shellfish consumed from the area is even lower, at less than one percent. Considering these data, 10 percent will be used for the CTE fractional Site-related intake for both finfish and shellfish in the BHHRA. There may be some differences between the fishing patterns that occur at Lavaca Bay compared to Galveston Bay and the Site, and therefore, a more conservative value of 25 percent will be adopted for the RME fractional Site-related intake for finfish and shellfish.

### Subsistence Fisher

There is no site-specific information available with which to estimate the fractional intake of fish and shellfish from the Site for the subsistence fisher. If subsistence activities do occur at the Site, it is possible that fishers participating in these activities may stay within closer proximity to the Site. Given the lack of Site-specific information, a conservative fractional intake of 1.0 will be adopted for the subsistence fisher.

## 4.2.2 *South Impoundment Area*

This section details the specific exposures that will be characterized and the exposure assumptions that will be adopted in the BHHRA for the south impoundment area.

### 4.2.2.1 *Receptor Groups and Exposure Scenarios*

Trespassers and workers are the human receptors for this area. Trespassers may walk around or spend time recreating within the south impoundment area. Workers may perform maintenance or other activities that may involve contact with soil. Potentially complete exposure pathways to be evaluated in the BHHRA for these groups include direct ingestion of and dermal contact with soil.

Table 7 presents the exposure scenarios that will be characterized in the BHHRA for the south impoundment area. The scenarios capture all of the potentially complete and significant exposure pathways described above and the exposure units for soil established in Section 3.4. They are:

- Trespasser—direct contact (i.e., ingestion of and dermal absorption) with surface soils at the single soil exposure unit defined.
- Worker—direct contact (i.e., ingestion of and dermal absorption) with surface and shallow subsurface soils at the single soil exposure unit defined.

### 4.2.2.2 *Exposure Assumptions for Trespasser Scenario*

USEPA does not offer specific guidance regarding the evaluation of exposures to trespassers for human health risk assessment. For the purposes of the BHHRA, it is assumed that the trespasser is an adolescent or young adult between the ages of 16 and 22 years, who

occasionally visits the south impoundment area. Exposure assumptions for the trespasser are summarized in Table 11.

The exposure duration for the trespasser is related to the assumed age group. For the RME, it will be assumed that the trespasser visits the Site from age 16 to < 23 (7 years), whereas for the CTE, it will be assumed that the trespasser visits the Site for approximately half of that duration (4 years).

The mean body weight of 74 kg for males and females age 16 to < 23 will be assumed (USEPA 2011b). Based on the assumption that a trespasser's hands, forearms, lower legs, and feet may come into contact with soils during time at the Site, a surface area value of 5,550 cm<sup>2</sup> will be used. A weighted soil adherence factor of 0.07 mg/cm<sup>2</sup>, based on data from a study of adults exposed to soil via a variety of types of contact activities, will be adopted (USEPA 2011b). A soil ingestion rate of 41 mg/kg will be used based on USEPA's (2011b) recommended soil ingestion rate of 50 mg/day for individuals ages 1 to < 21 years, and 20 mg/kg for individuals age 21 and older.

In the absence of any specific information about trespassing in the south impoundment area, exposure frequencies of 24 days/year and 12 days/year (i.e., an average of 2 days per month and 1 day per month throughout the course of the year) will be used to evaluate RME and CTE estimates, respectively. Considering the largely inaccessible nature of the south impoundment area, this assumption is reasonable. No site specific information (e.g., such as the amount of time trespassers spend at the Site for each visit they make) is available to inform the fraction of total daily soil exposure that is Site-related. In the instance that an individual does trespass on the Site, it is anticipated that his or her stay would be for only a few hours at most, and that the individual would also participate in other activities away from the Site where he or she would be exposed to soil. Based on best professional judgment, a fractional intake for direct contact with soil of 0.5 will be used for the RME analysis. A fractional intake of 0.25 will be used to evaluate the CTE.

#### **4.2.2.3 Exposure Assumptions for Worker Scenario**

For the BHHRA, the assumptions proposed by USEPA (2002d) for an outdoor worker have generally been selected. Exposure assumptions for the worker are summarized in Table 12 and discussed below.

USEPA's (2002c) default exposure duration of 25 years for workers will be used for the RME analysis. Twelve years will be adopted to evaluate CTE estimates, based on best professional judgment. An exposure frequency of 225 days/year for outdoor workers will be used (USEPA 2002c).

Outdoor workers are assumed to be adults and mean body weight for male and female adults of 80 kg will be used (USEPA 2011b). Following USEPA (2002c) guidance, it will be assumed that a worker's head, forearms, and hands may come into contact with Site soils. Based on this assumption, a mean surface area of 3,470 cm<sup>2</sup> was derived. USEPA's (2004) recommended soil adherence factor of 0.2 mg/cm<sup>2</sup> will be adopted. This recommendation is based on data for a wide variety of activities in which an outdoor worker may engage.

Based on the assumption that outdoor workers may be involved in contact-intensive activities, the recommended soil ingestion rate for outdoor workers of 100 mg/day will be used for the RME (USEPA 2002c). Because site workers may also be involved in less intensive activities, a rate of 50 mg/day will be used to evaluate the CTE estimates. This CTE is based on the recommended rate from USEPA (2002c) for an indoor worker.

It is reasonable to assume that workers may spend the majority of their waking hours at the Site so that the daily contribution from other sources may be minimal. Thus, the fractional intake for Site soil will be assumed as 1.0 for both RME and CTE estimates.

### **4.3 Chemical-Specific Exposure Parameters**

In addition to the scenario-specific exposure assumptions described above, there are a number of chemical specific factors that will be used to estimate COPCH-specific exposure levels. These include oral bioavailability and dermal absorption factors and chemical

reduction due to preparation and cooking. The chemical specific values selected for each are summarized in Table 15 and discussed below.

#### 4.3.1 **Relative Oral Bioavailability**

Bioavailability refers to the degree to which a substance becomes available to the target tissue after administration or exposure (USEPA 2011c). Following USEPA (1989) guidance, in the absence of data to the contrary, the bioavailability of COPCHs will be assumed to be 1.0.

Relative bioavailability is a measure of the extent of absorption that occurs for different forms of the same chemical (e.g., lead carbonate vs. lead acetate), different vehicles (e.g., food, soil, and/or water), or different dose levels. RBA factors for oral pathways are used to account for the differences in chemical bioavailability in specific exposure media (i.e., soil, sediment, tissue) compared to the dosing vehicle used in the critical toxicity study that provides the basis for the COPCH-specific toxicity criteria selected for use in the BHHRA.

For practical reasons, toxicity tests are usually designed using media that are expected to have high levels of bioavailability. The bioavailability of chemicals from other environmental matrices however, can be influenced by external factors such as the form of a compound (e.g., oxidation state), the length of time the chemical has been present (e.g., aging or weathering), and the physical characteristics of the medium (e.g., fraction of organic carbon in soil/sediment). It can also be influenced by internal biological factors such as absorption mechanisms within a living organism.

The relative bioavailability of a chemical in an environmental medium (e.g., soil, sediment, tissue) can be expressed as:

$$RBA = \frac{\text{absorbed fraction from exposure medium on site}}{\text{absorbed fraction from dosing medium used in toxicity study}} \times 100 \quad (\text{eq. 4-5})$$

Literature searches were conducted to identify appropriate RBA values for COPCHs that are anticipated to be risk drivers for the BHHRA for soil, sediment, and tissue. No information was available with which to quantify RBA<sub>tissue</sub>. Thus, in all cases, the RBA<sub>tissue</sub> will be assumed

to be 1.0, or 100 percent. The relative bioavailability of COPCHS in soils and sediments is discussed below.

The RBAs shown in Table 15 will be applied in the BHHRA. Uncertainties associated with the RBAs will be discussed in the uncertainty analysis of the BHHRA.

#### **4.3.2 Relative Bioavailability of Chemicals in Soils and Sediments**

Although relative bioavailability may differ between sediment and soil, existing data are currently insufficient to determine default RBAs for sediment. In the absence of site-specific information on bioavailability of sediment, USEPA and the Interstate and Technology Regulatory Council recommend that default factors for soil be adopted to evaluate sediment exposures (USEPA 2004; ITRC 2011).

Sufficient data with which to evaluate  $RBA_{\text{soil-sediment}}$  were available for dioxins and furans and for arsenic. The  $RBA_{\text{soil-sediment}}$  for each of these COPCHS is discussed below. A conservative default  $RBA_{\text{soil-sediment}}$  value of 1.0 will be assumed for the remainder of the COPCHS including cadmium, chromium, copper, mercury, nickel, thallium, PCBs, and BEHP. The uncertainty associated with the RBAs selected will be discussed in the uncertainty evaluation to be included in the BHHRA. The impact of alternative assumptions may be quantified for risk-driving COPCHS in soil and sediment.

##### **4.3.2.1 Dioxins/Furans**

USEPA (2010c) acknowledges that the relative bioavailability of dioxins and dioxin-like compounds in soils is less than 100 percent. In the Final Report, *Bioavailability of Dioxins and Dioxin-Like Compounds in Soil* USEPA (2010c), USEPA identified six studies that reported a total of 17 RBA test results for 2,3,7,8-TCDD in soil and sediment at concentrations ranging from 1.9 to 2,300 ng/g. The selected studies provided RBA estimates in test materials consisting of soil and sediment contaminated with dioxins *in situ*. The RBA for these studies ranges from less than 1 to 49 percent. Studies of spiked soil materials were not included in the analysis because aging of contaminated soil may decrease the bioavailability of dioxins in soil.

The high end of the soil and sediment concentrations of 2,3,7,8-TCDD and TEQ<sub>DF</sub> at the Site are within the range included in USEPA's review. Based on these data, an RBA<sub>soil-sediment</sub> of 0.5 will be applied for TEQ<sub>DF</sub> in the BHHRA.

#### 4.3.2.2 Arsenic

The relative bioavailability of inorganic arsenic in soil can vary due to differences in geochemical parameters and absorption mechanisms in receptor species. Several meta-analyses of arsenic bioavailability are available:

- USEPA (2010d) completed *in vivo* tests of 29 test materials from contaminated arsenic and clean sites using the Juvenile Swine Model. The test materials represented a large variety of arsenic phases (e.g., oxides, sulfates, phosphates). Discounting three tests that were determined to be unreliable due to levels of administered arsenic, estimated RBA values ranged from less than 10 to 61 percent with a mean of 34 percent. Based on these findings USEPA Region 8 concluded that an RBA of 0.50 as a generally conservative default value for inorganic arsenic (USEPA 2011d).
- Bioavailability studies conducted by Roberts et al. (2007) in cynomolgus monkeys measured the bioavailability of arsenic in 14 soil samples from 12 different sites, including mining and smelting sites, pesticide facilities, cattle dip vat soil, and chemical plant soil. The reported RBAs ranged from 5 to 31 percent.

Based on the available information, an RBA<sub>soil-sediment</sub> of 0.50 will be used in evaluating oral exposures to soil and sediment in the BHHRA.

#### 4.3.3 Dermal Absorption Factor for Soil and Sediment

The dermal absorption factor represents the proportion of a chemical that is absorbed across the skin from the soil and/or sediment matrix once contacted. Skin permeability is related to the solubility or strength of binding of the chemical in the soil or sediment matrix compared to the skin's *stratum corneum*. Therefore, dermal absorption is dependent on the properties of the chemical itself, as well as external factors including the physical properties of the soil or sediment matrix (e.g., particle size and organic carbon content) and the conditions of the skin (e.g., skin condition, moisture content).

Data with which to characterize dermal absorption of chemicals from sediment is not readily available and dermal absorption of chemicals from soil and sediment matrices will differ to some degree. In the absence of sediment-specific information, USEPA (2004) supports the adoption of factors derived for soil being applied to sediment.

USEPA's RAGS E Dermal Guidance (USEPA 2004) recommends dermal absorption factors for 10 chemicals for which well-designed studies were available at the date of its publication. In addition to USEPA's dermal guidance, sources including guidance from other regulatory entities and the peer reviewed literature were reviewed for available factors.

Dermal absorption factors for dioxins and furans, arsenic, PCBs, and BEHP were obtained from USEPA (2004). Those for chromium, mercury, and nickel were obtained from the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment's (OEHHA) Technical Support Document for Exposure Assessment and Stochastic Analysis, Draft (CalEPA 2011).

Following USEPA (2004) guidance, in the absence of available data for copper, thallium, and zinc, a conservative dermal absorption factor of 1.0 will be assumed for these COPCHS.

There is a degree of uncertainty in the representativeness of these dermal absorption factors for estimating potential exposure at the Site. Some of the more significant sources of uncertainty, focused around the COPCHS that are likely to drive risk at the Site, are discussed here.

- Observed ranges in absorption factors for a single chemical from different studies demonstrate large variability. For example, for PCBs, the default dermal absorption factor selected by USEPA and OEHHA is 14 percent. Another study (Mayes et al. 2002) that employed a similar methodology reported absorption ranging from 3 to 4 percent (CalEPA 2011). While some reasons for the large differences reported have been hypothesized, their influence has not been fully characterized.
- Organic carbon content also can have a substantial impact on dermal absorption. A chemical absorbed to the organic carbon phase will generally be less available

for transfer to skin than a chemical present in a separate liquid phase in the soil. Dermal bioavailability of a chemical in soil tends to decrease with increasing organic content of the soil (NEPI 2000; CalEPA 2011). Any difference between the organic carbon content in the test study matrix and at the Site may influence the applicability of the dermal absorption factor to the Site.

- Data for the full spectrum of dioxin-like congeners (i.e., to be evaluated as TEQ<sub>DF</sub> and TEQ<sub>P</sub>) is not available. The dermal absorption factor of 3 percent selected for this group of chemicals is based on a study of 2,3,7,8-TCDD (USEPA 2004). Thus, when the TEQ approach is used, it is inherently assumed that the absorption of all dioxin-like congeners is the same as the absorption of 2,3,7,8-TCDD. However, given differences in the chemical structure and properties of these compounds, it is likely that the degree of absorption differs substantially among them.

The dermal absorption factors shown in Table 15 will be applied in the baseline risk assessment. Uncertainties associated with the absorption factors used will be assessed in the uncertainty evaluation to be completed as part of the BHHRA.

#### **4.4 Chemical Reduction Due to Preparation and Cooking**

It is well recognized that tissue preparation and cooking methods used may reduce chemical concentrations in fish tissues, particularly for lipophilic compounds such as dioxins, furans, and PCBs (USEPA 2000a, 2002d; Wilson et al. 1998). These changes are dependent on a number of factors: the lipophilicity of the compound, the specific preparation and cooking method used by the consumers, the type of fish, and the parts of the fish consumed.

Specific information on the cooking methods used by fishers who catch and consume fish and shellfish at the Site has not been quantified. In addition, as discussed previously, species preferences for catch, harvest, and consumption at the Site have not been fully characterized.

Appendix C-1 of USEPA's Guidelines for Assessing Chemical Contamination Data for Use in Fish Advisories presents data on chemical loss due to preparation and cooking activities based on data from more than two dozen studies (USEPA 2000a). Reported cooking losses are highly variable depending on the chemical, study, species, and preparation and cooking

methods used. Loss for PCBs and dioxins for a wide array of preparation and cooking methods in a variety of tissue types ranged from 0 to 78 percent for PCBs, and 40 to 80 percent for dioxins. More recently available studies also report large ranges for cooking loss.

Although cooking loss appears to occur, the extent of dioxin, furan, and PCB cooking loss that occurs has not been well characterized in the published literature, and quantitative estimates of cooking losses remain uncertain. There were no consistent differences in losses among cooking methods in the studies reviewed. The range of methodologies used and differences in reporting likely explain some inconsistencies in the results. However, based on the available data, it is not possible to quantify the importance of specific factors influencing the extent of cooking losses for these chemicals.

Given the large degree of uncertainty in preparation and cooking methods used at the Site, coupled with the large degree of uncertainty and variability in actual loss via different preparation and cooking methods, a cooking loss term of 0 will conservatively be assumed for PCBs and dioxins. The impact of this assumption will be considered in the uncertainty evaluation to be completed as part of the BHHRA. The impact of using a cooking loss of 0.25 (25 percent loss) will be explored. This value is in line with cooking loss factors that have been developed for sites where more specific information on consumption and cooking methodologies are known (i.e., the Housatonic River Site).

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## **5 IMPLEMENTATION OF PROBABILISTIC EXPOSURE ASSESSMENT**

This section describes the use of probabilistic methods for estimating exposure at the Site. Specifically, it discusses the circumstances under which a probabilistic risk analysis (PRA) will be implemented, and the general approach that will be used in determining the specific parameters to be examined in the PRA. In addition, it presents, in general terms, the approaches that will be used in developing input distributions for exposure parameters.

### **5.1 Use of Probabilistic Methods**

Probabilistic analysis can provide a more complete and transparent characterization of exposure than a deterministic analysis. In probabilistic exposure assessment, data distributions are used to describe one or more exposure parameters. Multiple iterations of the risk equation are run, using different combinations of parameters to present a probability distribution of estimated exposure. The probabilistic output provides a more complete presentation of potential exposure and risk by considering both variability and uncertainty in parameter estimates, and ultimately offers insight into both the magnitude and probability of exposure.

USEPA recognizes that while a probabilistic assessment adds value for characterizing exposure in some cases, it may not be warranted in others. Factors to consider in deciding whether to proceed with a probabilistic assessment include 1) the results of the deterministic risk assessment, 2) the degree of variability and uncertainty associated with the input parameters, and 3) the potential impacts of the identified variability and uncertainty on overall estimates of exposure and risk.

Whether to implement a probabilistic analysis for the Site, and the specific exposure scenarios, pathways and parameters to be evaluated in that analysis will be dependent on the results of the deterministic BHHRA and the sensitivity and uncertainty analysis. Sensitivity analysis consists of evaluating the variation in output of a model following changes in the values of the model's input(s) (USEPA 2001). A sensitivity analysis allows the impact of individual parameter assumptions and their alternatives to be characterized in a systematic manner.

If the RME risk estimate (upper bound) associated with an exposure scenario is less than  $1 \times 10^{-4}$  and/or the hazard index is less than 1.0, a PRA will not be completed for that scenario. In addition, when the estimated risks or hazards resulting from a pathway that contributes significantly to risk or hazard are not greater than background risks, a probabilistic assessment will not be conducted.

If risks associated with the upper bound exposure estimates for a given scenario are unacceptable, however, the results of the CTE estimate and sensitivity analyses will be used to determine the impact that variability in exposure parameters has on the final risk estimate. If critical parameters that substantially influence the estimated exposures and associated risk are identified by the sensitivity analysis, a PRA may be conducted for one or more of the exposure pathways associated with that scenario. If completed, the PRA will be included as part of the BHHRA and considered in subsequent phases of the RI/FS.

## **5.2 Approach**

Any probabilistic assessment completed will be performed in a manner consistent with USEPA (2001) guidance for conducting PRA. If conducted, the probabilistic assessment will focus on the parameters that have the largest impacts on the overall estimates of exposure and risk. These may be factors that have a large range of potential values or be factors that have a substantial effect on the overall exposure estimate when combined with other factors (i.e., factors that are multiplicative). Distributions for these critical parameters will be developed using information obtained from the peer-reviewed literature.

It is anticipated that the fish and/or shellfish consumption pathways will play an important role in the overall risks for the Site. Therefore, it is likely that these pathways, if any, may be candidates for a more detailed probabilistic evaluation for some COPCHS. For the tissue consumption pathways, the critical parameters that are likely to warrant the development of input distributions include fish/shellfish ingestion rates, consumption preferences (which influence EPCs), fractional intake of fish and shellfish associated with the Site, preparation and cooking methods (which influence cooking loss), the cooking loss term itself, and the exposure duration.

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## 6 SUMMARY

This EAM provides an overview of the methods that will be used to estimate exposures to COPCHS by people who use the Site. It reviews the conceptual framework of pathways to be considered within the BHHRA, outlines the chemistry data considered representative for evaluating human exposures, and discusses the manner in which EPCs will be calculated. It additionally presents the exposure equations and general and chemical-specific parameters that will be used to estimate intake. Ultimately, these estimated intakes will be combined with toxicity criteria described in the Toxicological and Epidemiological Studies Memorandum (Integral 2012) to calculate risks and hazards at the Site.

Comments from USEPA on this draft EAM will be incorporated into a final EAM that will ultimately be included as an appendix to the draft BHHRA Report, which is scheduled to be delivered in July 2012.

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## TABLES

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**Table 1**  
**Chemicals of Potential Concern for Human Health**

<b>COPC<sub>H</sub></b>
<b>Dioxins/Furans</b>
Dioxins and Furans
<b>Metals</b>
Arsenic
Cadmium
Chromium
Copper
Mercury
Nickel
Thallium
Zinc
<b>Polychlorinated Biphenyls</b>
Polychlorinated Biphenyls
<b>Semivolatile Organic Compounds</b>
Bis(2-ethylhexyl)phthalate

**Notes**

COPC<sub>H</sub>s shown are for the area north of I-10 and the aquatic environment. Selection of COPC<sub>H</sub>s for the south impoundment area is in progress at the time of this submittal (Jan. 2012). Although thallium is not a COPC<sub>H</sub> according to analyses of information for the north impoundment, the maximum concentration of thallium measured in the south impoundment area exceeded the screening value for workers and, therefore, may be a COPC<sub>H</sub> for the south impoundment. It is therefore addressed in this memorandum.

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

**Table 2**  
**Chemicals of Potential Concern**

<b>Chemical</b>	<b>COPC Designation</b>
<b>Dioxins/Furans</b>	
Dioxins and Furans	EB, EFW, HH
<b>Metals</b>	
Aluminum	EB
Arsenic	HH
Barium	EB
Cadmium	EFW, HH
Chromium	HH
Cobalt	EB
Copper	EB, EFW, HH
Lead	EB
Magnesium	EB
Manganese	EB
Mercury	EB, EFW, HH
Nickel	EFW, HH
Thallium	EB
Vanadium	EB
Zinc	EB, EFW, HH
<b>Polychlorinated Biphenyls</b>	
Polychlorinated Biphenyls	EFW, HH
<b>Semivolatile Organic Compounds</b>	
Phenol	EB
Carbazole	EB
Bis(2-ethylhexyl)phthalate	EB, EFW, HH

**Notes**

EB = ecological receptors - benthic invertebrate community

EFW = ecological receptors - fish and wildlife

HH = human health receptors

**Table 3**  
**Summary of Data To Be Used in the BHHRA <sup>a</sup>**

Area and Medium	Study/Dataset	Sampling Period	Description of Samples Relevant for Human Health <sup>a</sup>	COPC <sub>s</sub> Evaluated
<b>On-Site Data for Area North of I-10 and Aquatic Environments</b>				
Sediment	URS 2010 (collected by TCEQ in 2009)	8/2009	Surface samples (0- to 6-inch) in the shoreline area around the north impoundment.	Dioxins/furans
	RI (TCRA)	4/2010	Surface samples (0- to 6-inch) in the north impoundment area.	Dioxins/furans
	RI	5/2010-6/2010 and 10/2010	Surface samples (0- to 6-inch) collected from 5 beach areas to evaluate human exposure. Additional surface samples (0- to 6-inch) collected within the shoreline area of the north impoundment.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors and dioxin-like congeners), BEHP
Soil	RI (TxDOT ROW)	8/2010	Surface samples ( 0- to 6-inch; 0- to 8-inch; 0- to 12-inch) collected alongside I-10.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors and dioxin-like congeners), BEHP
	RI (TCRA BSS)	11/2010	Surface samples (0- to 6-inch) collected to the west of the north impoundment.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors), BEHP
	RI (Groundwater study)	12/2010-1/2011	Surface samples (0- to 6-inch) collected in the area between I-10 and the north impoundment area.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, BEHP
	RI	2/2011	Surface samples (0- to 6-inch) collected throughout the area north of I-10.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, BEHP
Tissue	Univeristy of Houston and Parsons (2009)	5/2008, 8/2008, 5/2009	Atlantic croaker fillet(skin removed), Blue catfish fillet, and Hardhead catfish fillet (skin removed) from a single location within FCA 1. <sup>b</sup>	PCBs (congeners)
	RI	10/2010	Hardhead catfish fillet (skin removed), Blue crab (edible tissue) and Rangia cuneata clams (soft tissue) from 3 FCAs.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (congeners), BEHP
<b>On-Site Data for South Impoundment Area</b>				
Soil	RI (Phase I)	3/2011	Co-located surface and shallow subsurface samples (0- to 6-inch, 6- to 12-inch) collected at a subset of locations. Deeper surface samples (0 to 2 feet) collected at a subset of locations.	All COPCs (see Table 2)
	RI (Phase II)	planned for 2/2012	Co-located surface and shallow subsurface samples (0- to 6-inch, 6- to 12-inch).	Dioxin/furans. Potential for all COPCs (see Table 2) from archived soil.
<b>Background Data</b>				
Sediment	RI	5/2010, 8/2010, and 10/2011	Surface samples (0- to 6-inch) collected upstream of the Site.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (Aroclors and dioxin-like congeners), BEHP <sup>c</sup>
Soil	RI	2/2011	Co-located surface and shallow subsurface samples (0- to 6-inch, 6- to 12-inch) collected from two public parks.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, BEHP

**Table 3**  
**Summary of Data To Be Used in the BHHRA <sup>a</sup>**

Area and Medium	Study/Dataset	Sampling Period	Description of Samples Relevant for Human Health <sup>a</sup>	COPC <sub>s</sub> Evaluated
Tissue	Univeristy of Houston and Parsons (2009)	5/2008 - 8/2008, 5/2009	Hardhead catfish fillet collected downstream of the Site (locations downstream of the Fred Hartman bridge and additional samples located ~1,000 feet upstream of the Fred Hartman Bridge). <sup>c</sup>	PCBs (congeners)
	RI	10/2010 and 10/2011	Hardhead catfish fillet (skin removed), blue crab (edible) collected downstream of the Site; <i>Rangia cuneata</i> clams (soft tissue) collected from an upstream area.	Dioxins/furans, arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs (congeners), BEHP <sup>d</sup>

**Notes**

BEHP = bis(2-ethylhexyl)phthalate

BHHRA = baseline human health risk assessment

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

FCA = fish collection area

PCB = polychlorinated biphenyl

RI = remedial investigation

TCRA = time critical removal action

TxDOT ROW = Texas Department of Transportation right-of-way

a - All data to be used for the BHHRA are of Category 1 data validation. Data collected prior to 2005 were not included given the results of an analysis that showed sediment chemistry has changed since then. Only data relevant for the BHHRA (e.g., representative sample locations and depths to evaluate human exposures) are described.

b - Hardhead catfish fillet data will be included in the quantitative BHHRA based on the results of statistical tests to determine the appropriateness of pooling with data collected for the RI. See text in Section 3.4.2. Other tissue types will be considered in qualitative evaluations.

c - The inclusion of samples from two additional locations will increase the sample size so that a more robust exposure point concentration for hardhead catfish from this dataset to be calculated.

d - A subset of samples were analyzed for dioxins and furans only.

**Table 4**  
**Mammalian Toxicity Equivalency Factors for PCDDs, PCDFs, and PCBs**

Compound	TEF
<b>PCDDs</b>	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
All HxCDDs	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
<b>PCDFs</b>	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
All HxCDFs	0.1
All HpCDFs	0.01
OCDF	0.0003
<b>PCBs</b>	
3,3',4,4'-Tetrachlorinated biphenyl (PCB-77)	0.0001
3,4,4',5-Tetrachlorinated biphenyl (PCB-81)	0.0003
3,3',4,4',5-Pentachlorinated biphenyl (PCB-126)	0.1
3,3',4,4',5,5'-Hexachlorinated biphenyl (PCB-169)	0.03
2,3,3',4,4'-Pentachlorinated biphenyl (PCB-105)	0.00003
2,3,4,4',5-Pentachlorinated biphenyl (PCB-114)	0.00003
2,3',4,4',5-Pentachlorinated biphenyl (PCB-118)	0.00003
2',3,4,4',5-Pentachlorinated biphenyl (PCB-123)	0.00003
2,3,3',4,4',5-Hexachlorinated biphenyl (PCB-156)	0.00003
2,3,3',4,4',5'-Hexachlorinated biphenyl (PCB-157)	0.00003
2,3',4,4',5,5'-Hexachlorinated biphenyl (PCB-167)	0.00003
2,3,3',4,4',5,5'-Heptachlorinated biphenyl (PCB-189)	0.00003

**Source**

Van den Berg et al. (2006)

**Notes**

PCB = polychlorinated biphenyl

PCDD = polychlorinated dibenzo-*p*-dioxin

PCDF = polychlorinated dibenzofuran

TEF = toxicity equivalency factor

TCDD/TCDF = tetrachlorinated dibenzo dioxins/furans

PeCDD/PeCDF = pentachlorinated dibenzodioxins/furans

HxCDD/HxCDF = hexachlorinated dibenzodioxins/furans

HpCDD/HpCDF = heptachlorinated dibenzodioxins/furans

OCDD/OCDF = octachlorinated dibenzodioxins/furans

**Table 5**  
**PCB Congeners for Inclusion in Total PCB Summation**

PCB-8	PCB-81	PCB-128	PCB-177
PCB-18	PCB-87	PCB-138	PCB-180
PCB-28	PCB-99	PCB-151	PCB-183
PCB-37	PCB-101	PCB-153	PCB-187
PCB-44	PCB-105	PCB-156	PCB-189
PCB-49	PCB-110	PCB-157	PCB-194
PCB-52	PCB-114	PCB-158	PCB-195
PCB-66	PCB-118	PCB-167	PCB-201
PCB-70	PCB-119	PCB-168	PCB-206
PCB-74	PCB-123	PCB-169	PCB-209
PCB-77	PCB-126	PCB-170	

**Notes**

PCB = polychlorinated biphenyl

**Table 6**  
**Summary of Exposure Units for the BHHRA**

Medium		Scenario (Pre/Post TCRA)	Defined Exposure Unit	Sample Locations Included	Sample Depths Included	Number of Sampling Locations <sup>a</sup>	Detection Frequency for Exposure Unit	Figure Displaying Exposure Unit
Area North of I-10 and Aquatic Environments								
Sediment		Pre-TCRA	Beach Area A	SJSH036, -038, -040, -042, -044	0- to 6-inch	5	See Table D-1	Figure 7
			Beach Area B/C	SJSH017, -019, -021, -023, -025, -027, -029, -031, -033, -035	0- to 6-inch	10	See Table D-1	Figure 7
			Beach Area D	SJSH001, -002, -003, -004, -005, -012, -014	0- to 6-inch	7	See Table D-1	Figure 7
			Beach Area E	SJSH008, -009, -010; SJGB001, -006, -009, -010, -011, -012; SJNE022-1, -022-2, and -022-3; SJSV001; Point #1&2, Point #3; SJA1, SJA2	0- to 6-inch	17	See Table D-1	Figure 7
		Post-TCRA	Beach Area A	SJSH036, -038, -040, -042, -044	0- to 6-inch	5	See Table D-1	Figure 8
Tissue	Hardhead catfish fillet	Pre-TCRA	FCA 1	SJFCA1-LF1 to -LF 10, 11193	--	13	See Table D-2	Figure 9
			FCA 2/3	SJFCA2-LF1 to -LF 10; SJFCA3-LF1 to -LF 10	--	20	See Table D-2	Figure 9
	Edible clam	Pre-TCRA	FCA 1/3	CL-TTR1-001 to -005; CL-TTR6-001 to -005	--	10	See Table D-2	Figure 9
			FCA 2	CL-TTR3-001 to -005; CL-TTR4-001 to -005; CL-TTR5-001 to -005	--	15	SeeTable D-2	Figure 9
	Edible crab	Pre-TCRA	FCA 1	SJFCA1-CR1 to -CR10	--	10	See Table D-2	Figure 9
			FCA 2/3	SJFCA2-CR1 to -CR10; SJFCA3-CR1 to -CR10	--	20	See Table D-2	Figure 9
	All Types	Post-TCRA	Exposure units corresponding with pre-TCRA	No samples, modeled value	--	--	--	--
Soil		Pre-TCRA	Soils North of I-10	SJMWS01, -02, -03; SJTS001 to -031; TxDOT001 to -012	0- to 6-, 0- to 8-, and 0- to 12-inch	46	See Table D-3	Figure 10
		Post-TCRA	Soils North of I-10 <sup>POST-TCRA</sup> <sup>b</sup>	SJTS028 to -031; TxDOT001, -007	0- to 6-inch	6	See Table D-3	Figure 11

**Table 6**  
**Summary of Exposure Units for the BHHRA**

Medium	Scenario (Pre/Post TCRA)	Defined Exposure Unit	Sample Locations Included	Sample Depths Included	Number of Sampling Locations <sup>a</sup>	Detection Frequency for Exposure Unit	Figure Displaying Exposure Unit
South Impoundment <sup>c</sup>							
Soil	Pre-and Post-TCRA	Soils South of I-10	SJSB001 to -027; SJTS032 to -034	0- to 6-inch, 6- to 12-inch, <sup>d</sup> 0- to 2-foot	30	See Table D-4	Figure 12

**Notes**

-- = not applicable

BHHRA = baseline human health risk assessment

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

CWA = Coastal Water Authority

TCRA = time critical removal action

a - Sample size is across all analytes. Some COPC<sub>H</sub>s are sampled at a lower frequency. COPC<sub>H</sub>-specific detection frequency tables are provided in Appendix D.

b - Fencing constructed as part of the TCRA and by CWA limits accessible soils and sediments.

c - Phase I and Phase II sample locations are included here. Phase II sampling has not been completed at the time of this submittal (January 2012).

d - 0- to 6-inch and 6- to 12-inch samples are co-located. These two depths will be averaged, and the depth weighted average used for exposure assessment for workers. Only surface samples will be considered for trespassers.

**Table 7**  
**Summary of Exposure Scenarios for the BHHRA for Each Area**

Scenario <sup>a</sup>		Exposure Unit (EU) <sup>b</sup>			
		Sediment EU(s)	Soil EU(s)	Finfish EU(s)	Shellfish EU(s)
Area North of I-10 and Aquatic Environments					
Fisher (Recreational and Subsistence)					
Pre-TCRA	Scenario 1A	Beach Area A	--	Hardhead Catfish: FCA 2/3	--
	Scenario 1B	Beach Area A	--	--	Clam: FCA 1/3
	Scenario 1C	Beach Area A	--	--	Crab: FCA 2/3
	Scenario 2A	Beach Area B/C	--	Hardhead Catfish: FCA 2/3	--
	Scenario 2B	Beach Area B/C	--	--	Clam: 2
	Scenario 2C	Beach Area B/C	--	--	Crab: FCA 2/3
	Scenario 3A	Beach Area E	--	Hardhead Catfish: FCA 2/3	--
	Scenario 3B	Beach Area E	--	--	Clam: 2
	Scenario 3C	Beach Area E	--	--	Crab: FCA 2/3
	Scenario 4A	Beach Area D	--	Hardhead Catfish: FCA 1	--
	Scenario 4B	Beach Area D	--	--	Clam: FCA 1/3
	Scenario 4C	Beach Area D	--	--	Crab: FCA 1
Post-TCRA	Scenario 1	Beach Area A	--	Modeled values will be used, see text in Section 3.5.2	
Recreational Visitor					
Pre-TCRA	Scenario 1	Beach Area A	Soils North of I-10	--	--
	Scenario 2	Beach Area B/C	Soils North of I-10	--	--
	Scenario 3	Beach Area E	Soils North of I-10	--	--
	Scenario 4	Beach Area D	Soils North of I-10	--	--
Post-TCRA	Scenario 1	Beach Area A	Soils North of I-10 <sup>POST-TCRA</sup>	--	--
South Impoundment					
Trespasser					
Pre- and Post-TCRA	Scenario 1	--	Soils South of I-10	--	--
Worker					
Pre- and Post-TCRA	Scenario 1	--	Soils South of I-10	--	--

**Notes**

-- = Not applicable, exposure pathway not potentially complete per CSM and more refined conceptualization of the Site presented in Section 4 of the text.

BHHRA = baseline human health risk assessment

CSM = conceptual site model

EU = exposure unit

FCA = fish collection area

TCRA = time critical removal action

a - Post-TCRA scenarios assume that access to the Site continues to be restricted by fencing. Fence lines are displayed in Figures 4, 8, and 11.

b - Complete descriptions of the EUs are shown in Table 6.

**Table 8**  
**Exposure Assumptions for the North Impoundment Recreational Fisher**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Recreational Fisher

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soil:

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
Ingestion of Fish and Shellfish							
COPC <sub>H</sub> Terms, All Age Groups	COPC <sub>H</sub> concentration in fish	C <sub>fish</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			$I_{fish}(mg/kg-day) = C_{fish} \times (1-LOSS) \times IR_{fish} \times RBA_{food} \times FI_{fish,shellfish} \times EF_{fish,shellfish} \times ED \times CF/(BW \times AT)$  $I_{shellfish}(mg/kg-day) = C_{shellfish} \times (1-LOSS) \times IR_{shellfish} \times RBA_{food} \times FI_{fish,shellfish} \times EF_{fish,shellfish} \times ED \times CF/(BW \times AT)$  where: CF= 1E-03 kg/g
	COPC <sub>H</sub> concentration in shellfish	C <sub>shellfish</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			
	Chemical reduction due to preparation and cooking	LOSS	% as fraction	Chemical-specific, see Table 15			
	Relative food bioavailability adjustment	RBA <sub>food</sub>	% as fraction	Chemical-specific, see Table 15			
Adult	Ingestion rate, fish	IR <sub>fish</sub>	g/day	24	21	Alcoa (1998), study of Lavaca Bay. Based on 95UCL (RME) and arithmetic average (CTE) rates. Rates are averages for men and women combined.	
	Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	1.4	1.0	Alcoa (1998), study of Lavaca Bay. Based on 95UCL (RME) and arithmetic average (CTE) rates. Rates are averages for men and women combined.	
	Fraction of total fish or shellfish intake that is site-related	FI <sub>fish,shellfish</sub>	% as fraction	0.25	0.10	Site-specific; based on conservative interpretation from Alcoa (1998) study of Lavaca Bay.	
	Exposure frequency, fish, shellfish	EF <sub>fish,shellfish</sub>	days/year	365	365	Fish and shellfish ingestion rates are annualized daily averages.	
	Exposure duration	ED	years	16	12	USEPA (2011b). RME assumes summation with older child and young child age groups for a total of 33 years; CTE assumes 12 years as an adult.	
	Body weight	BW	kg	80	80	USEPA (2011b)	
	Averaging time - non-carcinogens	ATn	days	5,840	4,380	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Older Child (Age 7 to <18)	Ingestion rate, fish	IR <sub>fish</sub>	g/day	18	--	Alcoa (1998), study of Lavaca Bay. Based on 95UCL rate for youths.	
	Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	1.0	--	Alcoa (1998), study of Lavaca Bay. Based on 95UCL rate for youths.	
	Fraction of total fish or shellfish intake that is site-related	FI <sub>fish,shellfish</sub>	% as fraction	0.25	--	Site-specific; based on conservative interpretation from Alcoa (1998) study of Lavaca Bay.	
	Exposure frequency, fish, shellfish	EF <sub>fish,shellfish</sub>	days/year	365	--	Fish and shellfish ingestion rates are annualized averages.	
	Exposure duration	ED	years	11	--	USEPA (2011b). RME assumes summation with adult and young child age groups for a total of 33 years.	
	Body weight	BW	kg	50	--	USEPA (2011b). Average for 7 to <18 year age group.	
	Averaging time - non-carcinogens	ATn	days	4,015	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Young Child (Age 1 to <7)	Ingestion rate, fish	IR <sub>fish</sub>	g/day	14	--	Alcoa (1998), study of Lavaca Bay. Based on 95UCL rate for small children.	
	Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	0.6	--	Alcoa (1998), study of Lavaca Bay. Based on 95UCL rate for small children.	
	Fraction of total fish or shellfish intake that is site-related	FI <sub>fish,shellfish</sub>	% as fraction	0.25	--	Site-specific; based on conservative interpretation from Alcoa (1998) study of Lavaca Bay.	
	Exposure frequency, fish, shellfish	EF <sub>fish,shellfish</sub>	days/year	365	--	Fish and shellfish ingestion rates are annualized averages.	
	Exposure duration	ED	years	6	--	USEPA (2011b). RME assumes summation with adult and young child age groups for a total of 33 years.	
	Body weight	BW	kg	19	--	USEPA (2011b). Average for 1 to <7 year age group.	
	Averaging time - non-carcinogens	ATn	days	2,190	--	USEPA (1989); ED x 365 days/year	

**Table 8**  
**Exposure Assumptions for the North Impoundment Recreational Fisher**

CSM Area: North Impoundment Area and Aquatic Environment

Receptor: Recreational Fisher

Applicable Scenarios: Pre-TCRA, Post-TCRA

Exposure Pathways: Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soil:

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	
<b>Ingestion of Soil and Sediment</b>							
<b>COPC<sub>H</sub> Terms, All Age Groups</b>	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			
	COPC <sub>H</sub> concentration in sediment	C <sub>sed</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			
	Relative soil / sediment bioavailability adjustment	RBA <sub>ss</sub>	% as fraction	Chemical-specific, see Table 15			
<b>Adult</b>	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	20	20	USEPA (2011b)	$I_{\text{soil-sed}} \text{ (mg/kg-day)} = [(C_{\text{soil}} \times IR_{\text{soil}} \times F_{\text{soil}}) + (C_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}})] \times RBA_{ss} \times FI_{\text{soil-sed}} \times EF_{\text{soil-sed}} \times ED \times CF / (BW \times AT)$ <p align="center">where: CF= 1E-06 kg/mg</p>
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	20	20	USEPA (2011b). Based on ingestion rates for soil.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	0.5	BPJ	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	13	USFWS (2008); average trips per year for Texas residents fishing marine waters (CTE); professional judgment (RME) (see text).	
	Exposure duration	ED	years	16	12	USEPA (2011b). RME assumes summation with older child and young child age groups for a total of 33 years; CTE assumes 12 years as an adult.	
	Body weight	BW	kg	80	80	USEPA (2011b)	
	Averaging time - non-carcinogens	ATn	days	5,840	4,380	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
<b>Older Child (Age 7 to &lt;18)</b>	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	50	--	USEPA (2011b)	
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	50	--	USEPA (2011b); based on ingestion rates for soil.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	--	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	--	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	BPJ	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	--	Professional judgment; based on average trips per year for Texas residents fishing marine waters (see text).	
	Exposure duration	ED	years	11	--	USEPA (2011b). RME assumes summation with adult and young child age groups for a total of 33 years.	
	Body weight	BW	kg	50	--	USEPA (2011b). Average for 7 to <18 year age group.	
	Averaging time - non-carcinogens	ATn	days	4,015	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years	
<b>Young Child (Age 1 to &lt;7)</b>	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	125	--	USEPA (2011b); weighted average of recommended rates of 50 mg/day for 1,2, and 6 year olds and of 200 mg/day for 3 to 5 year olds.	

**Table 8**  
**Exposure Assumptions for the North Impoundment Recreational Fisher**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Recreational Fisher

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term	Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	125	--	USEPA (2011b); based on ingestion rates for soil, weighted average of recommended rates of 50 mg/day for 1,2, and 6 year olds and of 200 mg/day for 3 to 5 year olds.
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	--	Assumes soil exposure for the fisher is negligible compared to sediment exposure.
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	--	Assumes fisher is primarily exposed to sediment.
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	BPJ
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	--	Professional judgment; based on average trips per year for Texas residents fishing marine waters (see text).
	Exposure duration	ED	years	6	--	USEPA (2011b). RME assumes summation with adult and older child age groups for a total of 33 years.
	Body weight	BW	kg	19	--	USEPA (2011b). Average for 1 to <7 year age group
	Averaging time - non-carcinogens	ATn	days	2,190	--	USEPA (1989); ED x 365 days/year
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.
<b>Dermal Contact with Soil and Sediment</b>						
<b>COPC<sub>H</sub> Terms, All Age Groups</b>	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		
	COPC <sub>H</sub> concentration in sediment	C <sub>sed</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		
	Dermal absorption factor for soil/sediment	ABS <sub>d</sub>	% as fraction	Chemical-specific, see Table 15		
<b>Adult</b>	Skin surface area	SA	cm <sup>2</sup>	6,080	6,080	USEPA (2004, 2011b). Assumes forearms, hands, lower legs, and feet.
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	USEPA (2011b); values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	4.9	4.9	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	1	1	Assumes fisher is primarily exposed to sediment.
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	0.5	BPJ
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	13	USFWS (2008); rate for Texas residents fishing marine waters (CTE); BPJ (RME)
	Exposure duration	ED	years	16	12	USEPA (2011b). RME assumes summation with older child and young child age groups for a total of 33 years; CTE assumes 12 years as an adult.
	Event frequency	EV	1/day	1	1	USEPA (2004)

$$DAD_{\text{soil-sed}}(\text{mg/kg-day}) = DA_{\text{event}} \times SA \times EF_{\text{soil-sed}} \times FI_{\text{soil-sed}} \times ED \times EV / (BW \times AT)$$

where:

$$DA_{\text{event}}(\text{mg/cm}^2) = [(C_{\text{soil}} \times AF_{\text{soil}} \times F_{\text{soil}}) + (C_{\text{sed}} \times AF_{\text{sed}} \times F_{\text{sed}})] \times ABS_d \times CF$$

where:

$$CF = 1\text{E-}06 \text{ kg/mg}$$

**Table 8**  
**Exposure Assumptions for the North Impoundment Recreational Fisher**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Recreational Fisher

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
Older Child (Age 7 to <18)	Body weight	BW	kg	80	80	USEPA (2011b)	
	Averaging time - non-carcinogens	AT <sub>n</sub>	days	5,840	4,380	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	AT <sub>c</sub>	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
	Skin surface area	SA	cm <sup>2</sup>	4,270	--	USEPA (2004, 2011b); assumes forearms, hands, lower legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	--	USEPA (2011b); values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	5.1	--	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0	--	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	1	--	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	BPJ	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	--	BPJ based on USFWS (2008) mean rate for Texas residents fishing marine waters of 13 days per year.	
	Exposure duration	ED	years	11	--	USEPA (2011b). RME assumes summation with adult and young child age groups for a total of 33 years	
	Event frequency	EV	1/day	1	--	USEPA (2004)	
	Body weight	BW	kg	50	--	USEPA (2011b). Average for 7 to <18 year age group	
	Averaging time - non-carcinogens	AT <sub>n</sub>	days	4,015	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	AT <sub>c</sub>	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Young Child (Age 1 to <7)	Skin surface area	SA	cm <sup>2</sup>	3,280	--	USEPA (2004, 2011b); assumes forearms, hands, lower and upper legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.09	--	USEPA (2011b); values are based on study of children exposed to soil; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	3.6	--	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0	--	Assumes soil exposure for the fisher is negligible compared to sediment exposure	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	1	--	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	BPJ	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	--	BPJ based USFWS (2008) mean rate for Texas residents fishing marine waters of 13 days per year.	

Table 8  
Exposure Assumptions for the North Impoundment Recreational Fisher

CSM Area: North Impoundment Area and Aquatic Environment

Receptor: Recreational Fisher

Applicable Scenarios: Pre-TCRA, Post-TCRA

Exposure Pathways: Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
	Exposure duration	ED	years	6	--	USEPA (2011b). RME assumes summation with adult and older child age groups for a total of 33 years.	
	Event frequency	EV	1/day	1	--	USEPA (2004)	
	Body weight	BW	kg	19	--	USEPA (2011b). Average for 1 to <7 year age group.	
	Averaging time - non-carcinogens	ATn	days	2,190	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	

Notes

- = not applicable
- ADD = average daily dose
- BPJ = best professional judgment
- COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment
- CTE = central tendency exposure
- DAD = dermally absorbed dose
- I = intake (daily)
- LADD = lifetime average daily dose
- RME = reasonable maximum exposure

a - LADD will be calculated as the sum of I or DAD across all age groups for whom exposure is assumed to occur. ADD will be assumed as the I or DAD from the age group with the highest intake

**Table 9**  
**Exposure Assumptions for the North Impoundment Subsistence Fisher**

CSM Area: North Impoundment Area and Aquatic Environment

Receptor: Subsistence Fisher

Applicable Scenarios: Pre-TCRA, Post-TCRA

Exposure Pathways: Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term	Units	Value	Rationale/Reference	Exposure Equations <sup>a</sup>
<b>Ingestion of Fish &amp; Shellfish</b>					
<b>COPC<sub>H</sub> Terms, All Age Groups</b>	COPC <sub>H</sub> concentration in fish	C <sub>fish</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs	$I_{fish}(mg/kg-day) = C_{fish} \times (1-LOSS) \times IR_{fish} \times RBA_{food} \times FI_{fish,shellfish} \times EF_{fish,shellfish} \times ED \times CF/(BW \times AT)$
	COPC <sub>H</sub> concentration in shellfish	C <sub>shellfish</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs	
	Chemical reduction due to preparation and cooking	LOSS	% as fraction	Chemical-specific, see Table 15	
	Relative Food Bioavailability Adjustment	RBA <sub>food</sub>	% as fraction	Chemical-specific, see Table 15	
<b>Adult</b>	Ingestion rate, fish	IR <sub>fish</sub>	g/day	58	$I_{shellfish}(mg/kg-day) = C_{shellfish} \times (1-LOSS) \times IR_{shellfish} \times RBA_{food} \times FI_{fish,shellfish} \times EF_{fish,shellfish} \times ED \times CF/(BW \times AT)$
	Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	3.8	
	Fraction of total fish or shellfish intake that is site-related	FI <sub>fish,shellfish</sub>	% as fraction	1	
	Exposure frequency, fish, shellfish	EF <sub>fish,shellfish</sub>	days/year	365	
	Exposure duration	ED	years	16	
	Body weight	BW	kg	80	
	Averaging time - non-carcinogens	ATn	days	5,840	
	Averaging time - carcinogens	ATc	days	28,470	
<b>Older Child (Age 7 to &lt;18)</b>	Ingestion rate, fish	IR <sub>fish</sub>	g/day	45	$I_{fish}(mg/kg-day) = C_{fish} \times (1-LOSS) \times IR_{fish} \times RBA_{food} \times FI_{fish,shellfish} \times EF_{fish,shellfish} \times ED \times CF/(BW \times AT)$
	Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	4.5	
	Fraction of total fish or shellfish intake that is site-related	FI <sub>fish,shellfish</sub>	% as fraction	1	
	Exposure frequency, fish, shellfish	EF <sub>fish,shellfish</sub>	days/year	365	
	Exposure duration	ED	years	11	
	Body weight	BW	kg	50	
	Averaging time - non-carcinogens	ATn	days	4,015	
	Averaging time - carcinogens	ATc	days	28,470	
<b>Young Child (Age 1 to &lt;7)</b>	Ingestion rate, fish	IR <sub>fish</sub>	g/day	30	$I_{fish}(mg/kg-day) = C_{fish} \times (1-LOSS) \times IR_{fish} \times RBA_{food} \times FI_{fish,shellfish} \times EF_{fish,shellfish} \times ED \times CF/(BW \times AT)$
	Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	2.0	
	Fraction of total fish or shellfish intake that is site-related	FI <sub>fish,shellfish</sub>	% as fraction	1	
	Exposure frequency, fish, shellfish	EF <sub>fish,shellfish</sub>	days/year	365	
	Exposure duration	ED	years	6	
	Body weight	BW	kg	19	
	Averaging time - non-carcinogens	ATn	days	2,190	

where:  
CF= 1E-03 kg/g

**Table 9**  
**Exposure Assumptions for the North Impoundment Subsistence Fisher**

CSM Area: North Impoundment Area and Aquatic Environment

Receptor: Subsistence Fisher

Applicable Scenarios: Pre-TCRA, Post-TCRA

Exposure Pathways: Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	Value	Rationale/Reference	Exposure Equations <sup>a</sup>
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989), USEPA (2011b); based on life expectancy of 78 years.	
Ingestion of Soil and Sediment						
COPC <sub>H</sub> Terms, All Age Groups	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		$I_{\text{soil-sed}} \text{ (mg/kg-day)} = ([C_{\text{soil}} \times IR_{\text{soil}} \times F_{\text{soil}}] + [C_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}}]) \times RBA_{\text{ss}} \times FI_{\text{soil-sed}} \times EF_{\text{soil-sed}} \times ED \times CF / (BW \times AT)$  where: CF= 1E-06 kg/mg
	COPC <sub>H</sub> concentration in sediment	C <sub>sed</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		
	Relative Soil / Sediment Bioavailability Adjustment	RBA <sub>ss</sub>	% as fraction	Chemical-specific, see Table 15		
Adult	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	20	USEPA (2011b)	
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	20	USEPA (2011b). Based on ingestion rates for soil.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	16	USEPA (2011b). Assumes summation with older child and young child age groups for a total of 33 years.	
	Body weight	BW	kg	80	USEPA (2011b)	
	Averaging time - non-carcinogens	ATn	days	5,840	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989), USEPA (2011b); based on life expectancy of 78 years.	
Older Child (Age 7 to <18)	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	50	USEPA (2011b)	
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	50	USEPA (2011b); based on ingestion rates for soil.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	11	USEPA (2011b). Assumes summation with adult and young child age groups for a total of 33 years.	
	Body weight	BW	kg	50	USEPA (2011b). Average for 7 to <18 year age group.	
	Averaging time - non-carcinogens	ATn	days	4,015	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Young Child (Age 1 to <7)	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	125	USEPA (2011b); weighted average of recommended rates of 50 mg/day for 1,2, and 6 year olds and of 200 mg/day for 3 to 5 year olds.	
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	125	USEPA (2011b); based on ingestion rates for soil, weighted average of recommended rates of 50 mg/day for 1,2, and 6 year olds and of 200 mg/day for 3 to 5 year olds.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	

**Table 9**  
**Exposure Assumptions for the North Impoundment Subsistence Fisher**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Subsistence Fisher

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	Value	Rationale/Reference	Exposure Equations <sup>a</sup>
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	6	USEPA (2011b). Assumes summation with adult and older child age groups for a total of 33 years.	
	Body weight	BW	kg	19	USEPA (2011b). Average for 1 to <7 year age group.	
	Averaging time - non-carcinogens	ATn	days	2,190	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Dermal Contact with Soil and Sediment						
COPC <sub>H</sub> Terms, All Age Groups	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		DAD <sub>soil-sed</sub> (mg/kg-day) = DA <sub>event</sub> x SA x EF <sub>soil-sed</sub> x FI <sub>soil-sed</sub> x ED x EV/(BW x AT)  where: DA <sub>event</sub> (mg/cm <sup>2</sup> ) = [(C <sub>soil</sub> x AF <sub>soil</sub> x F <sub>soil</sub> )+(C <sub>sed</sub> x AF <sub>sed</sub> x F <sub>sed</sub> )] x ABS <sub>d</sub> x CF  where: CF= 1E-06 kg/mg
	COPC <sub>H</sub> concentration in sediment	C <sub>sed</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		
	Dermal absorption factor for soil/sediment	ABS <sub>d</sub>	% as fraction	Chemical-specific, see Table 15		
Adult	Skin surface area	SA	cm <sup>2</sup>	6,080	USEPA (2004, 2011b). Assumes forearms, hands, lower legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	USEPA (2011b); values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	4.9	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	16	USEPA (2011b). Assumes summation with older child and young child age groups for a total of 33 years.	
	Event frequency	EV	1/day	1	USEPA (2004)	
	Body weight	BW	kg	80	USEPA (2011b)	
	Averaging time - non-carcinogens	ATn	days	5,840	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Older Child (Age 7 to <18)	Skin surface area	SA	cm <sup>2</sup>	4,270	USEPA (2004, 2011b); assumes forearms, hands, lower legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	USEPA (2011b); values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	5.1	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	

**Table 9**  
**Exposure Assumptions for the North Impoundment Subsistence Fisher**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Subsistence Fisher

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of fish and shellfish, Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	Value	Rationale/Reference	Exposure Equations <sup>a</sup>
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	11	USEPA (2011b). Assumes summation with adult and young child age groups for a total of 33 years.	
	Event frequency	EV	1/day	1	USEPA (2004)	
	Body weight	BW	kg	50	USEPA (2011b). Average for 7 to <18 year age group.	
	Averaging time - non-carcinogens	ATn	days	4,015	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Young Child (Age 1 to <7)	Skin surface area	SA	cm <sup>2</sup>	3,280	USEPA (2004, 2011b); assumes forearms, hands, lower and upper legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.09	USEPA (2011b); values are based on study of children exposed to soil; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	3.6	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0	Assumes soil exposure for the fisher is negligible compared to sediment exposure.	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	1	Assumes fisher is primarily exposed to sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	6	USEPA (2011b). Assumes summation with adult and older child age groups for a total of 33 years.	
	Event frequency	EV	1/day	1	USEPA (2004)	
	Body weight	BW	kg	19	USEPA (2011b). Average for 1 to <7 year age group.	
	Averaging time - non-carcinogens	ATn	days	2,190	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	

**Notes**

ADD = average daily dose

BPJ = best professional judgment

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

DAD = dermally absorbed dose

I = intake (daily)

LADD = lifetime average daily dose

a - LADD will be calculated as the sum of I or DAD across all age groups for whom exposure is assumed to occur. ADD will be assumed as the I or DAD from the age group with the highest intake.

**Table 10**  
**Exposure Assumptions for the North Impoundment Recreational Visitor**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Recreational Visitor

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term	Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>	
Ingestion of Soil and Sediment							
COPC <sub>H</sub> Terms, All Age Groups	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		$I_{\text{soil-sed}} \text{ (mg/kg-day)} = ([C_{\text{soil}} \times IR_{\text{soil}} \times F_{\text{soil}}] + [C_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}}]) \times RBA_{\text{ss}} \times FI_{\text{soil-sed}} \times EF_{\text{soil-sed}} \times ED \times CF / (BW \times AT)$  where: CF = 1E-06 kg/mg	
	COPC <sub>H</sub> concentration in sediment	C <sub>sed</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			
	Relative soil / sediment bioavailability adjustment	RBA <sub>ss</sub>	% as fraction	Chemical-specific, see Table 15			
Adult	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	20	20		USEPA (2011b)
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	20	20		USEPA (2011b); based on ingestion rates for soil.
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0.5	0.5		Assumes half of visitor's direct exposure is with soil.
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	0.5	0.5		Assumes half of visitor's direct exposure is with sediment.
	Fraction of total daily intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	0.5		Site-specific; based on BPJ.
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	52		BPJ. Assumes average exposure of 2 days per week (RME) and 1 day per week (CTE) throughout the year, 52 weeks per year.
	Exposure duration	ED	years	16	12		USEPA (2011b). RME assumes summation with older child and young child age groups for a total of 33 years; CTE assumes 12 years as an adult.
	Body weight	BW	kg	80	80	USEPA (2011b)	
	Averaging time - non-carcinogens	ATn	days	5,840	4,380	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Older Child (Age 7 to <18)	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	50	--	USEPA (2011b)	
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	50	--	USEPA (2011b); based on ingestion rates for soil.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with soil.	
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with sediment.	
	Fraction of total daily intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	--	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	11	--	USEPA (2011b). RME assumes summation with adult and young child age groups for a total of 33 years.	
	Body weight	BW	kg	50	--	USEPA (2011b); average for 7- to <18-year age group.	
	Averaging time - non-carcinogens	ATn	days	4,015	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	

**Table 10**  
**Exposure Assumptions for the North Impoundment Recreational Visitor**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Recreational Visitor

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
Young Child (Age 1 to <7)	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	125	--	USEPA (2011b); weighted average of recommended rates of 50 mg/day for 1,2, and 6 year olds and of 200 mg/day for 3 to 5 year olds.	
	Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	125	--	USEPA (2011b); based on ingestion rates for soil, weighted average of recommended rates of 50 mg/day for 1,2, and 6 year olds and of 200 mg/day for 3 to 5 year olds.	
	Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with soil.	
	Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with sediment.	
	Fraction of total daily intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	--	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	6	--	USEPA (2011b). RME assumes summation with adult and older child age groups for a total of 33 years.	
	Body weight	BW	kg	19	--	USEPA (2011b); average for 1- to <7-year age group.	
	Averaging time - non-carcinogens	ATn	days	2,190	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	
Dermal Contact with Soil and Sediment							
COPC <sub>H</sub> Terms, All Age Groups	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			$DAD_{soil-sed} (mg/kg-day) = DA_{event} \times SA \times EF_{soil-sed} \times ED \times FI_{soil-sed} \times EV / (BW \times AT)$  where: $DA_{event} (mg/cm^2) = (C_{soil} \times AF_{soil} \times F_{soil}) + (C_{sed} \times AF_{sed} \times F_{sed}) \times ABS_d \times CF$  where: CF= 1E-06 kg/mg
	COPC <sub>H</sub> concentration in sediment	C <sub>sed</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			
	Dermal Absorption Factor for Soil/Sediment	ABS <sub>d</sub>	% as fraction	Chemical-specific, see Table 15			
Adult	Skin surface area	SA	cm <sup>2</sup>	6,080	6,080	USEPA (2004, 2011b). Assumes forearms, hands, lower legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	USEPA (2011b): values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	4.9	4.9	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0.5	0.5	Assumes half of visitor's direct exposure is with soil.	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	0.5	0.5	Assumes half of visitor's direct exposure is with sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	0.5	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	52	BPJ. Assumes average exposure of 2 days per week (RME) and 1 day per week (CTE) throughout the year, 52 weeks per year.	

**Table 10**  
**Exposure Assumptions for the North Impoundment Recreational Visitor**

**CSM Area:** North Impoundment Area and Aquatic Environment

**Receptor:** Recreational Visitor

**Applicable Scenarios:** Pre-TCRA, Post-TCRA

**Exposure Pathways:** Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
	Exposure duration	ED	years	16	12	USEPA (2011b). RME assumes summation with older child and young child age groups for a total of 33 years; CTE assumes 12 years as an adult.	
	Event frequency	EV	1/day	1	1	USEPA (2004)	
	Body weight	BW	kg	80	80	USEPA (2011b)	
	Averaging time - non-carcinogens	ATn	days	5,840	4,380	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	
<b>Older Child (Age 7 to &lt;18)</b>	Skin surface area	SA	cm <sup>2</sup>	4,270	--	USEPA (2004, 2011b); assumes forearms, hands, lower legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	--	USEPA (2011b): values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	5.1	--	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with soil.	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with sediment.	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	Site-specific; conservative assumption based on BPJ.	
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	--	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	11	--	USEPA (2011b). RME assumes summation with adult and young child age groups for a total of 33 years.	
	Event frequency	EV	1/day	1	--	USEPA (2004)	
	Body weight	BW	kg	50	--	USEPA (2011b). Average for 7 to <18 year age group.	
	Averaging time - non-carcinogens	ATn	days	4,015	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	
<b>Young Child (Age 1 to &lt;7)</b>	Skin surface area	SA	cm <sup>2</sup>	3,280	--	USEPA (2004, 2011b); assumes forearms, hands, lower and upper legs, and feet.	
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.09	--	USEPA (2011b): values are based on study of children exposed to soil; weighted average of adherence factors for exposed body parts.	
	Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	3.6	--	USEPA (2011b); values are based on study of children playing in sediment; weighted average of adherence factors for exposed body parts.	
	Fraction of pathway exposure to soil	F <sub>soil</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with soil.	
	Fraction of pathway exposure to sediment	F <sub>sed</sub>	% as fraction	0.5	--	Assumes half of visitor's direct exposure is with sediment	
	Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	--	Site-specific; based on conservative interpretation from Alcoa (1998) study of Lavaca Bay.	

**Table 10**  
**Exposure Assumptions for the North Impoundment Recreational Visitor**

**CSM Area:** North Impoundment Area and Aquatic Environment  
**Receptor:** Recreational Visitor  
**Applicable Scenarios:** Pre-TCRA, Post-TCRA  
**Exposure Pathways:** Ingestion of sediment/soils, Dermal absorption of sediment/soils

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>
	Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	104	--	BPJ. Assumes average exposure of 2 days per week throughout the year, 52 weeks per year.	
	Exposure duration	ED	years	6	--	USEPA (2011b). RME assumes summation with adult and older child age groups for a total of 33 years.	
	Event frequency	EV	1/day	1	--	USEPA (2004)	
	Body weight	BW	kg	19	--	USEPA (2011b); average for 1- to <7-year age group.	
	Averaging time - non-carcinogens	ATn	days	2,190	--	USEPA (1989); ED x 365 days/year	
	Averaging time - carcinogens	ATc	days	28,470	--	USEPA (1989, 2011b); based on life expectancy of 78 years.	

**Notes**  
 -- = not applicable  
 ADD = average daily dose  
 BPJ = best professional judgment  
 COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment  
 CTE = central tendency exposure  
 DAD = dermally absorbed dose  
 I = Intake (daily)  
 LADD = lifetime average daily dose  
 RME = reasonable maximum exposure  
 a - LADD will be calculated as the sum of I or DAD across all age groups for whom exposure is assumed to occur. ADD will be assumed as the I or DAD from the age group with the highest intake

**Table 11**  
**Exposure Assumptions for the South Impoundment Trespasser**

CSM Area: South Impoundment Area

Receptor: Trespasser

Applicable Scenarios: Pre-TCRA/Post-TCRA

Exposure Pathways: Ingestion of soil, Dermal absorption of soil

Exposure Pathway and Receptor	Term		Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>	
Ingestion of Soil								
COPC <sub>H</sub> Terms	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs			I <sub>soil</sub> (mg/kg-day)= C <sub>soil</sub> × IR <sub>soil</sub> × RBA <sub>ss</sub> × FI <sub>soil</sub> × EF <sub>soil</sub> × ED × CF/ (BW × AT)  where: CF= 1E-06 kg/mg	
	Relative soil bioavailability adjustment	RBA <sub>ss</sub>	% as fraction	Chemical-specific, see Table 15				
Trespasser (Age 16 to <23 )	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	41	41	USEPA (2011b); based on ingestion rates for soil, weighted average of recommended rates of 50 mg/day for 16 to <21 year olds and 20 mg/kg for 21 and 22 year olds.		
	Fraction of total daily soil intake that is site-related.	FI <sub>soil</sub>	% as fraction	0.5	0.25	Site-specific; assumption based on BPJ.		
	Exposure frequency, soil	EF <sub>soil</sub>	days/year	24	12	BPJ. Assumes average exposure of 2 days per month (RME) and 1 day per month(CTE) throughout the year.		
	Exposure duration	ED	years	7	4	Based on assumed age group; CTE based on BPJ.		
	Body weight	BW	kg	74	74	USEPA (2011b); average for 16 to <23 year age-group.		
	Averaging time - non-carcinogens	ATn	days	2,555	1,460	USEPA (1989); ED x 365 days/year		
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.		
Dermal Contact with Soil								
COPC <sub>H</sub> Terms	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs				DAD <sub>soil</sub> (mg/kg-day) = DA <sub>event</sub> × SA × EF <sub>soil</sub> × ED × FI <sub>soil</sub> × EV/ (BW × AT)  where: DA <sub>event</sub> (mg/cm <sup>2</sup> ) = C <sub>soil</sub> × AF <sub>soil</sub> × ABS <sub>d</sub> × CF  where: CF= 1E-06 kg/mg
	Dermal Absorption Factor for Soil	ABS <sub>d</sub>	% as fraction	Chemical-specific, see Table 15				
Trespasser (Age 16 to <23 )	Skin surface area	SA	cm <sup>2</sup>	5,550	5,550	USEPA (2004, 2011b); assumes forearms, hands, lower legs, and feet.		
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	USEPA (2011b); values are based on studies of adults exposed to soil by way of various activities; weighted average of adherence factors for exposed body parts.		
	Fraction of total daily soil intake that is site-related.	FI <sub>soil</sub>	% as fraction	0.5	0.25	Site-specific; assumption based on BPJ.		
	Exposure frequency, soil	EF <sub>soil</sub>	days/year	24	12	BPJ. Assumes average exposure of 2 days per month (RME) and 1 day per month(CTE) throughout the year.		
	Exposure duration	ED	years	7	4	Based on assumed age group; CTE based on BPJ.		
	Event frequency	EV	1/day	1	1	USEPA (2004)		
	Body weight	BW	kg	74	74	USEPA (2011b); average for 16- to <23 year age group.		
	Averaging time - non-carcinogens	ATn	days	2,555	1,460	USEPA (1989); ED x 365 days/year		
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.		

**Notes**

ADD = average daily dose

BPJ = best professional judgment

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

CTE = central tendency exposure

DAD = dermally absorbed dose

I = intake (daily)

LADD = lifetime average daily dose

RME = reasonable maximum exposure

a - LADD and ADD will be assumed as I or DAD for the single age group presented.

**Table 12**  
**Exposure Assumptions for the South Impoundment Worker**

CSM Area: South Impoundment Area

Receptor: Worker

Applicable Scenarios: Pre-TCRA/Post-TCRA

Exposure Pathways: Ingestion of soil, Dermal absorption of soil

Exposure Pathway and Receptor	Term	Units	RME	CTE	Rationale/Reference	Exposure Equations <sup>a</sup>	
Ingestion of Soil							
COPC <sub>H</sub> Terms	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		I <sub>soil</sub> (mg/kg-day)= C <sub>soil</sub> × IR <sub>soil</sub> × RBA <sub>ss</sub> × FI <sub>soil</sub> × EF <sub>soil</sub> × ED × CF/ (BW × AT)  where: CF= 1E-06 kg/mg	
	Relative soil bioavailability adjustment	RBA <sub>ss</sub>	% as fraction	Chemical-specific, see Table 15			
Adult Worker	Ingestion rate, soil	IR <sub>soil</sub>	mg/day	100	50		USEPA (2002c); recommended values for outdoor (RME) and indoor (CTE) workers.
	Fraction of total daily soil intake that is site-related.	FI <sub>soil</sub>	% as fraction	1	1		Site-specific
	Exposure frequency, soil	EF <sub>soil</sub>	days/year	225	225		USEPA (2002c); recommended value for outdoor worker.
	Exposure duration	ED	years	25	12		USEPA (2002c) (RME); BPJ (CTE)
	Body weight	BW	kg	80	80		USEPA (2011b)
	Averaging time - non-carcinogens	ATn	days	9,125	4,380		USEPA (1989); ED x 365 days/year
	Averaging time - carcinogens	ATc	days	28,470	28,470		USEPA (1989, 2011b); based on life expectancy of 78 years.
Dermal Contact with Soil							
COPC <sub>H</sub> Terms	COPC <sub>H</sub> concentration in soil	C <sub>soil</sub>	mg/kg	Chemical-specific, see Section 3.5 on EPCs		DAD <sub>soil</sub> (mg/kg-day) = DA <sub>event</sub> × SA × EF <sub>soil</sub> × ED × FI <sub>soil</sub> × EV/ (BW × AT)  where: DA <sub>event</sub> (mg/cm <sup>2</sup> ) = C <sub>soil</sub> × AF <sub>soil</sub> × ABS <sub>d</sub> × CF  where: CF= 1E-06 kg/mg	
	Dermal absorption factor for soil	ABS <sub>d</sub>	% as fraction	Chemical-specific, see Table 15			
Adult Worker	Skin surface area	SA	cm <sup>2</sup>	3,470	3,470		USEPA (2004, 2011b). Assumes head, forearms, and hands.
	Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.2	0.2		USEPA (2004): central tendency weighted adherence factors for exposed body parts based on high-end soil contact activity for commercial/industrial workers.
	Fraction of total daily soil intake that is site-related.	FI <sub>soil</sub>	% as fraction	1	1		Site-specific; conservative assumption based on BPJ.
	Exposure frequency, soil	EF <sub>soil</sub>	days/year	225	225		USEPA (2002c); recommended value for outdoor worker.
	Exposure duration	ED	years	25	12		USEPA (2002c) (RME); BPJ (CTE)
	Event frequency	EV	1/day	1	1		USEPA (2004); central tendency weighted adherence factors for exposed body parts based on high-end soil contact activity for commercial/industrial workers.
	Body weight	BW	kg	80	80		USEPA (2011b); based on adult
	Averaging time - non-carcinogens	ATn	days	9,125	4,380		USEPA (1989); ED x 365 days/year
	Averaging time - carcinogens	ATc	days	28,470	28,470	USEPA (1989, 2011b); based on life expectancy of 78 years.	

**Notes**

ADD = average daily dose

BPJ = best professional judgment

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

CTE = central tendency exposure

DAD = dermally absorbed dose

I = intake (daily)

LADD = lifetime average daily dose

RME = reasonable maximum exposure

a - LADD and ADD will be assumed as I or DAD for the single age group presented.

**Table 13**  
**Summary of Exposure Assumptions for All Receptors, North Impoundment Area**

Units			Recreational Fisher				Subsistence Fisher			Recreational Visitor			
			RME			CTE	RME			RME			CTE
			Adult	Older Child	Young Child	Adult	Adult	Older Child	Young Child	Adult	Older Child	Young Child	Adult
<b>All Pathways</b>													
Body weight	BW	kg	80	50	19	80	80	50	19	80	50	19	80
Exposure duration	ED	years	16	11	6	12	16	11	6	16	11	6	12
Averaging time - non-carcinogens	ATn	days	5,840	4,015	2,190	4,380	5,840	4,015	2,190	5,840	4,015	2,190	4,380
Averaging time - carcinogens	ATc	days	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470	28,470
<b>Ingestion of Fish and Shellfish</b>													
Exposure frequency, fish, shellfish	EF <sub>fish-shellfish</sub>	days/year	365	365	365	365	365	365	365	--	--	--	--
Ingestion rate, fish	IR <sub>fish</sub>	g/day	24	18	14	21	58	45	30	--	--	--	--
Ingestion rate, shellfish	IR <sub>shellfish</sub>	g/day	1.4	1.0	0.6	1.0	3.8	4.5	2.0	--	--	--	--
Fraction of total fish or shellfish intake that is site-related	FI <sub>fish-shellfish</sub>	% as fraction	0.25	0.25	0.25	0.10	1	1	1	--	--	--	--
<b>Ingestion of Soil and Sediment</b>													
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	39	39	13	104	104	104	104	104	104	52
Ingestion rate, soil	IR <sub>soil</sub>	mg/day	20	50	125	20	20	50	125	20	50	125	20
Ingestion rate, sediment	IR <sub>sed</sub>	mg/day	20	50	125	20	20	50	125	20	50	125	20
Fraction of total ingestion that is soil	F <sub>soil</sub>	% as fraction	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
Fraction of total ingestion that is sediment	F <sub>sed</sub>	% as fraction	1	1	1	1	1	1	1	0.5	0.5	0.5	0.5
Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	1	1	0.5	1	1	1	1	1	1	0.5
<b>Dermal Contact with Soil and Sediment</b>													
Exposure frequency; soil, sediment	EF <sub>soil-sed</sub>	days/year	39	39	39	13	104	104	104	104	104	104	52
Skin surface area	SA	cm <sup>2</sup>	6,080	4,270	3,280	6,080	6,080	4,270	3,280	6,080	4,270	3,280	6,080
Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	0.09	0.07	0.07	0.07	0.09	0.07	0.07	0.09	0.07
Adherence factor, sediment	AF <sub>sed</sub>	mg/cm <sup>2</sup>	4.9	5.1	3.6	4.9	4.9	5.1	3.6	4.9	5.1	3.6	4.9
Fraction of pathway exposure that is soil	F <sub>soil</sub>	% as fraction	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5
Fraction of pathway exposure that is sediment	F <sub>sed</sub>	% as fraction	1	1	1	1	1	1	1	0.5	0.5	0.5	0.5
Fraction of total daily soil/sediment intake that is site-related.	FI <sub>soil-sed</sub>	% as fraction	1	1	1	0.5	1	1	1	1	1	1	0.5
Event frequency	EV	1/day	1	1	1	1	1	1	1	1	1	1	1

**Notes**

Chemical-specific parameters, including relative bioavailability, dermal absorption, and reduction due to preparation and cooking factors are shown in Table 15.

-- = Not applicable; pathway is not evaluated for receptor.

CTE = central tendency exposure

RME = reasonable maximum exposure

**Table 14**  
**Summary of Exposure Assumptions for All Receptors, South Impoundment Area**

		Units	Trespasser		Worker	
			RME	CTE	RME	CTE
All Pathways						
Body weight	BW	kg	74	74	80	80
Exposure duration	ED	years	7	4	25	12
Fraction of total daily soil intake that is site-related.	FI <sub>soil</sub>	% as fraction	0.5	0.25	1	1
Exposure frequency, soil	EF <sub>soil</sub>	days/year	24	12	225	225
Averaging time - non-carcinogens	ATn	days	2,555	1,460	9,125	4,380
Averaging time - carcinogens	ATc	days	28,470	28,470	28,470	28,470
Ingestion of Soil						
Ingestion rate, soil	IR <sub>soil</sub>	mg/day	41	41	100	50
Dermal Contact with Soil						
Skin surface area	SA	cm <sup>2</sup>	5,550	5,550	3,470	3,470
Adherence factor, soil	AF <sub>soil</sub>	mg/cm <sup>2</sup>	0.07	0.07	0.2	0.2
Event frequency	EV	1/day	1	1	1	1

**Notes**

Chemical-specific parameters, including relative bioavailability, and dermal absorption factors are shown in Table 15.

CTE = central tendency exposure

RME = reasonable maximum exposure

**Table 15**  
**Summary of Chemical-Specific Exposure Parameters**

	Dermal Absorption Factor for Soil/Sediment (ABS <sub>d</sub> ) (% as fraction)		Relative Soil / Sediment Bioavailability Adjustment (RBA <sub>ss</sub> ) (% as fraction)		Relative Food Bioavailability Adjustment (RBA <sub>tissue</sub> ) (% as fraction)		Chemical Reduction Due to Preparation and Cooking (LOSS) (% as fraction)	
COPC <sub>H</sub>								
Dioxins/Furans								
Dioxins and Furans	0.03	a	0.5	b	1	d	0	d
Metals								
Arsenic (inorganic)	0.03	a	0.5	b	1	d	0	d
Cadmium	0.001	a	1	d	1	d	0	d
Chromium	0.02	c	1	d	1	d	0	d
Copper	1	d	1	d	1	d	0	d
Mercury	0.03	c	1	d	1	d	0	d
Nickel	0.04	c	1	d	1	d	0	d
Thallium	1	d	1	d	--		--	
Zinc	1	d	1	d	1	d	0	d
Polychlorinated Biphenyls								
Polychlorinated Biphenyls	0.14	a	1	d	1	d	0	d
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	0.1	a	1	d	1	d	0	d

**Notes**

-- = Not applicable; not a COPC<sub>H</sub> in this medium.

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

a - Value is from USEPA (2004).

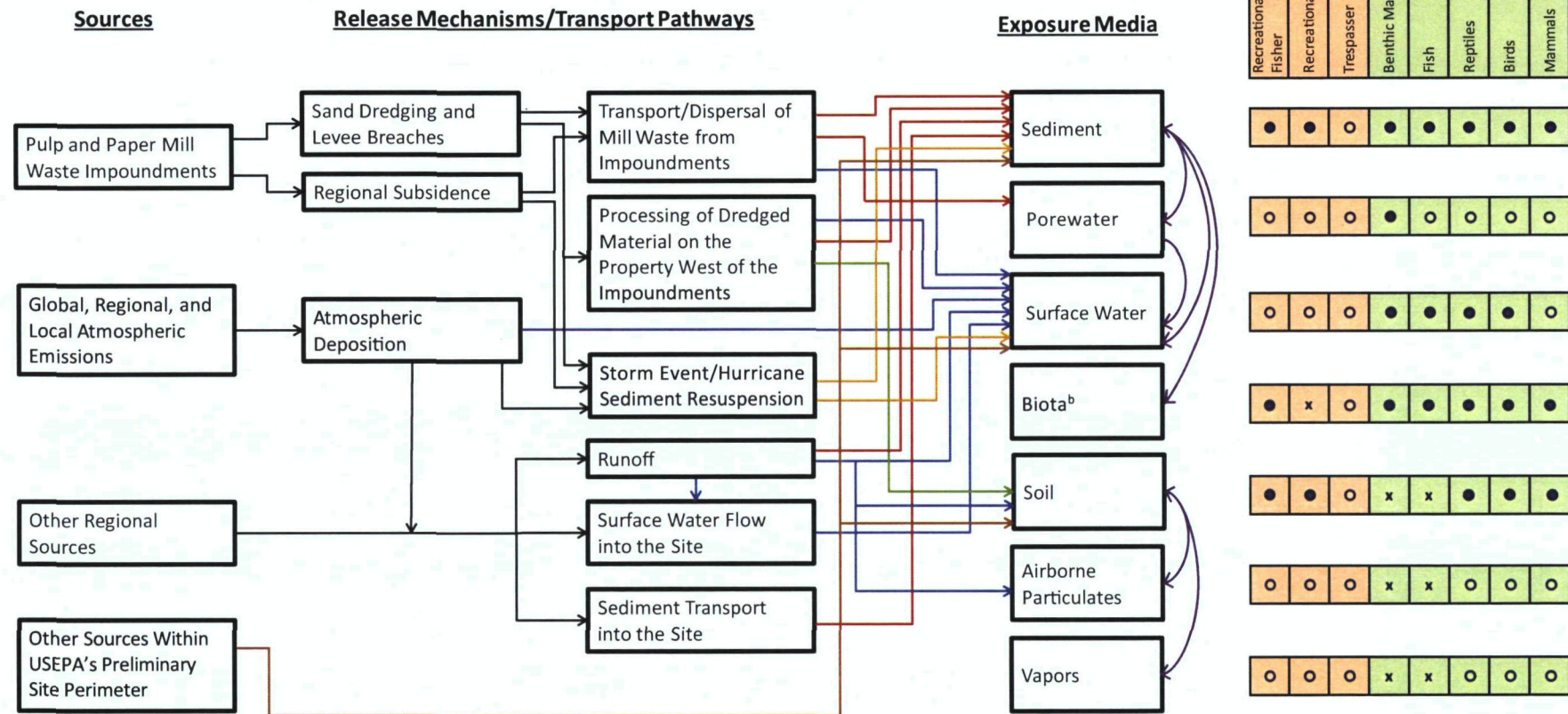
b - Multiple sources were used to derive this value (see Section 4.3.2 of text).

c - Value is from CalEPA (2011).

d - Conservative default assumption.

## FIGURES

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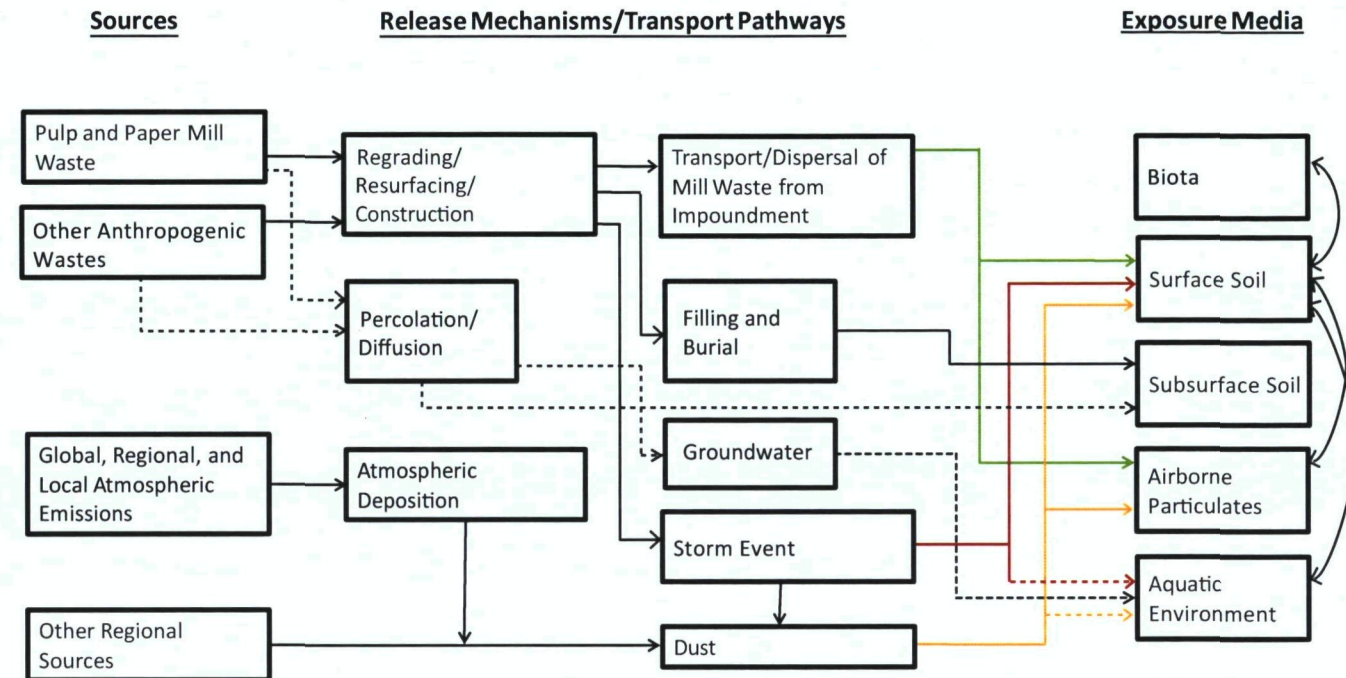
**Notes:**

Other regional sources may include industrial effluents, publicly owned treatment works, and stormwater.

Curved lines indicate potential transport pathways for chemicals of potential concern among exposure media.

<sup>a</sup>Benthic macroinvertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds, and mammals.

<sup>b</sup>Biota consumed by human receptors are expected to be fish and shellfish.



### Potential Receptors of Concern

Human	Ecological			
Trespasser/Worker	Reptiles	Terrestrial Birds	Mammals	Aquatic Receptors
×	●	●	●	×
●	●	●	●	×
○	○	×	○	×
○	○	○	○	×
×	○	×	×	○

#### Notes:

Local sources may include industrial air emissions, vehicle or machinery fluid leaks, or other releases resulting from ongoing commercial activities on the site. Curved lines indicate potential transport pathways for chemicals of potential concern among exposure media.

● Complete, significant exposure pathway

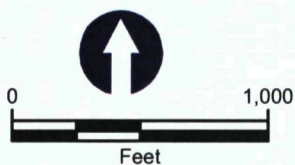
○ Complete, minor exposure pathway

×

----- Unknown pathway



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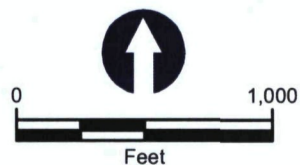
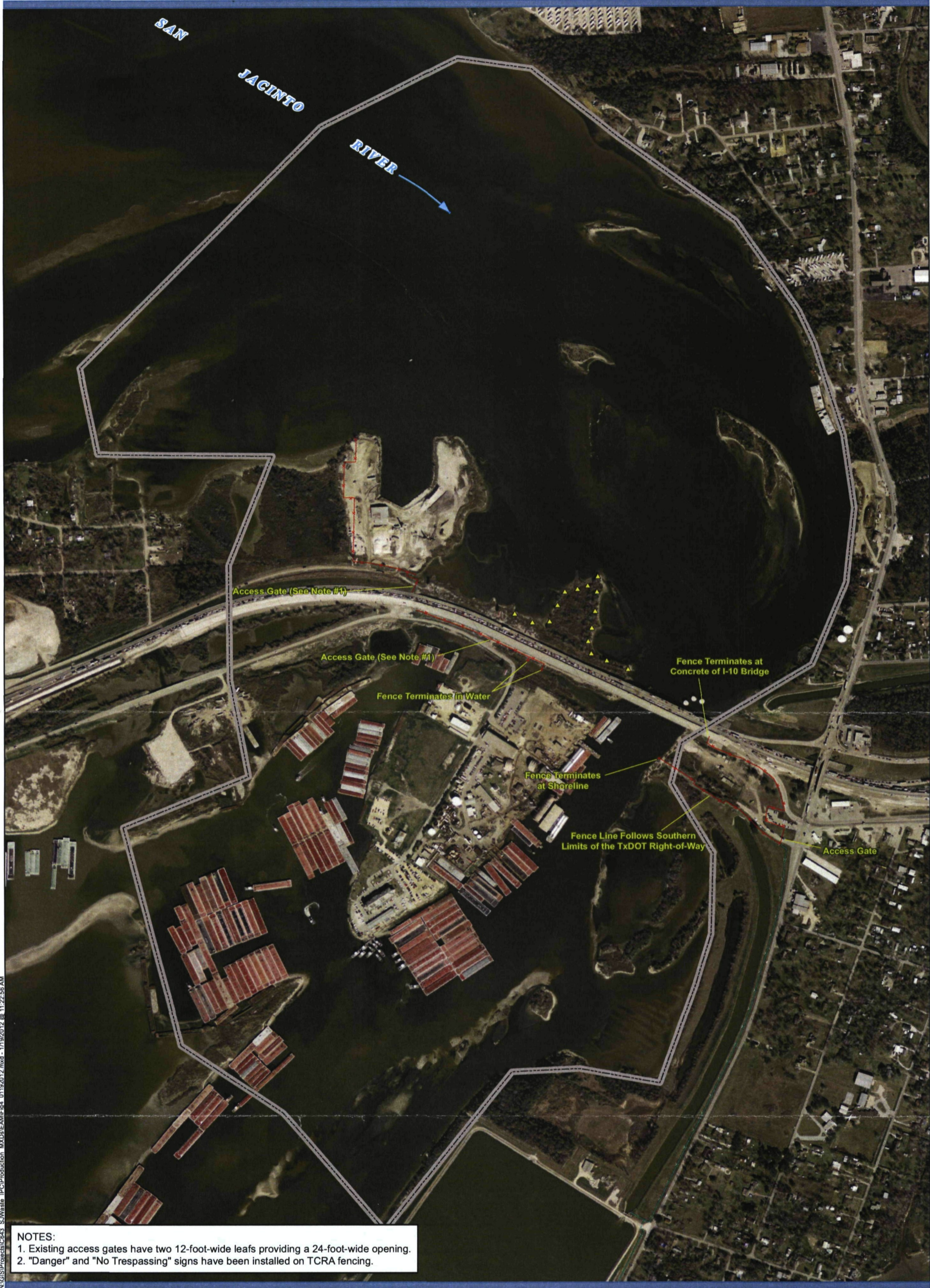


- USEPA's Preliminary Site Perimeter
- Original (1966) Perimeter of the Northern Impoundments
- Area of Soil Investigation South of I-10

\* Designation of the sand separation area is intended to be a general reference to areas in which such activities are believed to have taken place based on visual observations of aerial photography from 1998 through 2002.

FEATURE SOURCES:  
Aerial Imagery: 0.5-meter, Photo Date: 01/14/2009  
Texas Strategic Mapping Program (StratMap), TNRIS

**Figure 3**  
Overview of Area within USEPA's Preliminary Site Perimeter  
SJRW Exposure Assessment Memorandum  
SJRW Superfund/MIMC and IPC



- △ Approximate Location of "Danger" and "No Trespassing" Signs
- TCRA Fence Line
- Coastal Water Authority Fence Line
- ▭ USEPA's Preliminary Site Perimeter

**Figure 4**  
Fencing Introduced as Part of the Time Critical Removal Action and by the Coastal Water Authority  
SJRW Exposure Assessment Memorandum  
SJRW Superfund/MIMC and IPC

		<u>Potential Human Receptors of Concern</u>		
<u>Exposure Media</u>	<u>Exposure Route</u>	Recreational and Subsistence Fishers	Recreational Visitor	Trespasser
Sediment	Ingestion	●	●	○
	Dermal Contact	●	●	○
Porewater	Dermal Contact	○	○	○
Surface Water	Ingestion	○	○	○
	Dermal Contact	○	○	○
Fish and Shellfish	Ingestion	●	x	○
Soil	Ingestion	●	●	○
	Dermal Contact	●	●	○
Airborne Particulates	Inhalation	○	○	○
Vapors	Inhalation	○	○	○

- Potentially complete and significant exposure pathway
- Potentially complete but minor exposure pathway
- x Incomplete exposure pathway

		Potential Human Receptors of Concern
Exposure Media	Exposure Route	Trespasser/Worker
Soil	Ingestion	●
	Dermal contact	●
Airborne Particulates	Inhalation	○

Notes:

- Potentially complete and significant exposure pathway
- Potentially complete but minor exposure pathway



**Figure 7**  
 Exposure Units for Sediment, Area North of I-10 and Aquatic Environments, Pre-TCRA  
 SJRWP Exposure Assessment Memorandum  
 SJRWP Superfund/MIMC and IPC



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consulting inc.

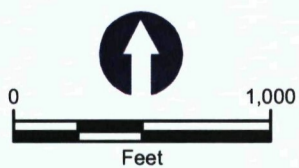
0 1,000  
Feet

- Surface Sediment Sampling Locations
  - Exposure Unit Designation
  - ✕✕✕ TCRA Fence Line
  - ✕✕✕ Coastal Water Authority Fence Line
  - ▭ 0 Contour (NAVD 88)<sup>a</sup>
  - ▭ USEPA's Preliminary Site Perimeter
- Note: <sup>a</sup> Tidal conditions under which this contour was measured are unknown.

**Figure 8**  
Exposure Units for Sediment, Area North of I-10 and Aquatic Environments, Post-TCRA  
SJRW Exposure Assessment Memorandum  
SJRW Superfund/MIMC and IPC

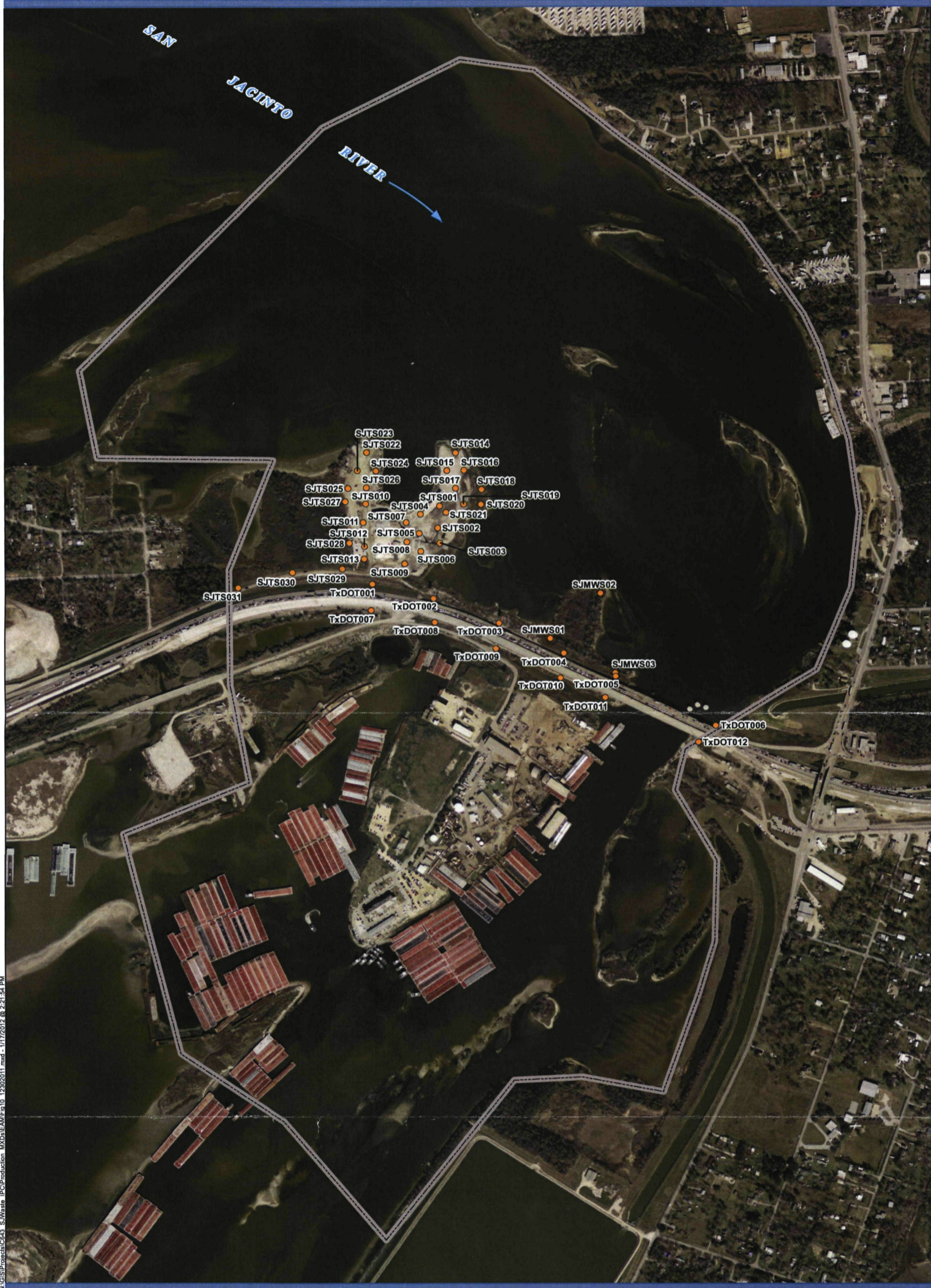


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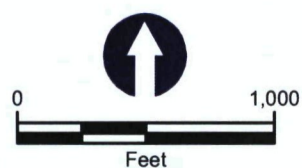


- Large Fish Collection Location (University of Houston and Parsons, 2009)
- ▬ Large Fish and Blue Crab Fish Collection Area
- ▬ Hardhead Catfish Fillet and Blue Crab Exposure Unit: "FCA 1"
- ▬ Hardhead Catfish Fillet and Blue Crab Exposure Unit: "FCA 2/3"
- ▬ Clam Exposure Unit: "FCA 1/3"
- ▬ Clam Exposure Unit: "FCA 2"
- ▬ Original (1966) Perimeter of the Northern Impoundments
- ▬ USEPA's Preliminary Site Perimeter

**Figure 9**  
Exposure Units for Fish and Shellfish Tissue, Area North of I-10 and Aquatic Environments, Pre-TCRA  
SJRWEP Exposure Assessment Memorandum  
SJRWEP Superfund/MIMC and IPC



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- Surface Soil Sampling Locations
- USEPA's Preliminary Site Perimeter

**Figure 10**  
 Exposure Unit for Soils, Area North of I-10 and  
 Aquatic Environments, Pre-TCRA  
 SJRWP Exposure Assessment Memorandum  
 SJRWP Superfund/MIMC and IPC



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- Surface Soil Sampling Locations
- ✕✕✕ TCRA Fence Line
- ✕✕✕ Coastal Water Authority Fence Line
- ▬ USEPA's Preliminary Site Perimeter

**Figure 11**  
Exposure Unit for Soils, Area North of I-10 and  
Aquatic Environments, Post-TCRA  
SJRW Exposure Assessment Memorandum  
SJRW Superfund/MIMC and IPC



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consulting inc.

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Feet

- Planned Soil Core 0-2 Ft Interval Dioxins, Furans, Grainsize, TOC and All COPCs will be Analyzed <sup>a</sup>
- Planned Soil Core 0-2 Ft Interval, Dioxins, Furans, Grainsize and TOC will be Analyzed <sup>a</sup>
- ⊕ Planned Monitoring Well and Colocated Soil Core <sup>a</sup>
- Existing Soil Core with All COPCs Analyzed (0-2 Ft Interval)
- Existing Soil Core, Dioxins and Furans Only (0-2 Ft Interval)
- Existing Surface and Shallow Subsurface Core with All COPCs Analyzed (0-6 and 6-12 Inches)

NOTES:  
<sup>a</sup> The upper 2 feet will be divided into 0-6, 6-12 and 12-24 inch increments.

**Figure 12**  
 Exposure Unit for Surface and Shallow  
 Subsurface Soils, South Impoundment  
 Area Pre- and Post- TCRA  
 SJRWP Exposure Assessment Memorandum  
 SJRWP Superfund/MIMC and IPC

**APPENDIX A**  
**QUALITY ASSURANCE REVIEW OF PCB**  
**CONGENER DATA FROM THE TMDL**  
**PROGRAM**

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## 1 OVERVIEW OF APPENDIX A

This Appendix to the Exposure Assessment Memorandum provides independent quality assurance (QA) review of tissue and sediment samples collected from April 2008 through June 2009 in association with the Houston Ship Channel Dioxin Total Maximum Daily Load (TMDL) study for polychlorinated biphenyl (PCB) congeners (University of Houston and Parsons 2009, 2010). A subset of this tissue and sediment dataset is useful in support of the San Jacinto River Waste Pits remedial investigation and feasibility study (RI/FS) to characterize both baseline conditions on the Site, and tissue concentrations in background areas.

All of the data to be used for decision-making in the RI/FS must meet certain QA criteria to ensure that they are appropriate for the intended use. The data classification scheme used to characterize the extent and documentation of QA review required for any given dataset is described in Section 3.1 of the RI/FS Work Plan (Anchor QEA and Integral 2010). The result of this process is classification of discrete datasets into one of two categories: Category 1, data of known quality that are appropriate for use in decision making; and Category 2, data of unknown or suspect quality (data may be initially classified as Category 2 data because supporting QA data were not available or had not been sought out). For data in Category 2 to be reclassified as Category 1, an independent QA review and documentation of that review are necessary. This appendix provides the documentation of an independent QA review of two datasets from the TCEQ's TMDL program for PCBs:

- Attachment A-1. PCB congeners in tissue collected for TCEQ's TMDL program for PCBs. Only data collected in 2008 and 2009 were evaluated.
- Attachment A-2. PCB congeners in sediment collected for TCEQ's PCB TMDL program at Station 11193, which is within USEPA's preliminary Site perimeter.

---

## 2 REFERENCES

- Anchor QEA and Integral, 2010. Final Remedial Investigation/Feasibility Study Work Plan, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Prepared by Anchor QEA, LLC (Ocean Springs, MS) and Integral Consulting Inc. (Seattle, WA). November 2010.
- University of Houston and Parsons, 2009. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-22. Quarterly Report No. 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:  
<http://www.tceq.texas.gov/assets/public/implementation/water/tmdl/78hscpcbs/78-2009marchquarterly.pdf>.
- University of Houston and Parsons, 2010. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-29. Quarterly Report No. 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:  
<http://www.tceq.texas.gov/assets/public/implementation/water/tmdl/78hscpcbs/78-2010marchquarterly.pdf>.

**ATTACHMENT A-1**  
**DATA VERIFICATION SUMMARY**  
**REPORT: TISSUE**

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## 1 INTRODUCTION

Tissue samples were collected from April 2008 through June 2009 in association with the Houston Ship Channel Dioxin Total Maximum Daily Load (TMDL) study (University of Houston and Parsons 2009, 2010). Chemistry data that are not collected according to an approved sampling and analysis plan but which are to be used in the remedial investigation and feasibility study (RI/FS) must undergo a quality assurance (QA) review to ensure that the data are appropriate for specified uses, such as support of decision making. This process is described in Section 3.1 of the RI/FS Work Plan (Anchor QEA and Integral 2010) and classifies the data into two categories: Category 1, data of known quality that are appropriate for use in decision making, and Category 2, data of unknown or suspect quality. Tissue data for polychlorinated biphenyl (PCB) congeners from the TMDL study were initially classified as Category 2 data because supporting QA data were not available. Two QA evaluations of the 2008 and 2009 tissue samples were obtained and used to independently validate those tissue data. This Attachment A-1 documents a review of those QA evaluations to reclassify these data as Category 1. The samples reviewed are listed in Table 1.

## 2 EVALUATION

Data classification requires evaluation of the following factors:

- Traceability
- Comparability
- Sample integrity
- Potential measurement bias (i.e., accuracy, precision).

For data to be classified as Category 1 all of these factors must be known or supported by existing QA/QC information including: analytical methods, chain-of-custody, sample holding time, method blanks, matrix spike/matrix spike duplicates, laboratory control samples, replicates, and surrogates. The evaluation of these factors was documented in Appendix D-1 of the RI/FS Work Plan.

Data verification summary reports prepared by Parsons of Austin, Texas, were obtained from the Texas Commission on Environmental Quality (TCEQ)<sup>1</sup> to reevaluate the data for the 2008–2009 TMDL tissues. Data verification summary reports are included as Attachments A1.1 and A1.2. The sections below discuss the QA/QC information documented in these reports. These data verification summary reports discuss additional samples not included in

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<sup>1</sup> <http://www.tceq.texas.gov/waterquality/tmdl/78-hsc-pcbs.html>

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Table 1. Some QA exceptions that are discussed in the reports do not apply to the samples in Table 1.

The following flags were assigned by Parsons personnel during their review of the 2008–2009 TMDL tissue data:

<b>Flag Key for 2008–2009 TMDL Tissue Data</b>	
F	Field duplicate exceedance
B	Blank contamination
Q	Limit of quantitation exceedance

## **2.1 Analytical Method**

All 2008 tissue samples were analyzed by Maxxam Analytical Inc. of Burlington, Canada. All 2009 tissue samples were analyzed by Pace Analytical Services, Inc. of Minneapolis, MN. All samples were analyzed by the analytical method specified in the Quality Assurance Project Plan (QAPP; Rifai 2008 and 2009) for the TMDL study, U.S. Environmental Protection Agency (USEPA) Method 1668A (USEPA 2003).

## **2.2 Chain of Custody**

All chain of custody procedures followed those described in the QAPP for the TMDL study.

## **2.3 Holding Times**

The method specified analytical holding time of one year from sample collection to sample extraction was met for all samples listed in Table 1.

## **2.4 Method Blanks**

The method blank frequency criteria (one for every 20 samples or one per extraction batch) set forth in the QAPP were met. The method blanks had many PCBs above the reporting limits. Sample results that were less than 5 times the amount found in the blank were “B” flagged to indicate the method blank contamination. Select tissue data from 2009 were “B” flagged to indicate method blank contamination; these data should be assessed as being estimated values.

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## **2.5 Matrix Spikes/Matrix Spike Duplicates**

Recoveries in the matrix spike/matrix spike duplicates (MS/MSD) met the control limits (60 to 140 percent) specified in the QAPP, with the exception of analytes in parent samples having analyte concentrations greater than 4 times the amount spiked. No results were flagged based on MS/MSD recoveries.

## **2.6 Laboratory Control Samples**

Recoveries in the laboratory control samples met the control limits (50 to 150 percent) specified in the QAPP. No results were flagged based on laboratory control sample recoveries.

## **2.7 Replicates**

Precision was evaluated using the relative percent difference (RPD) obtained from the parent sample/field duplicate sample results. All field duplicate results were within the control limit of 50 percent less than RPD specified in the QAPP, except for select PCB congeners; these results were flagged "F" as estimated as a result of the out-of-tolerance RPD.

## **2.8 Labeled Compounds**

Recoveries of labeled compounds met the criteria specified in the analytical method (USEPA Method 1668A). No results were flagged based on labeled compound recoveries.

## **2.9 Limit of Quantitation**

Most of the 2008–2009 tissue sample results met the limits of quantitation (LOQ) specified in the QAPP. Select PCB congeners within this dataset exceeded QAPP LOQs and were "Q" flagged by Parsons.

## **3 CONCLUSION**

The samples discussed in this memorandum were collected and analyzed following the QAPP and analytical procedures. No reported results were rejected or invalidated. Based on the above review the PCB congener data for the samples listed in Table 1 are acceptable and of known quality and can be considered to be Category 1 data.

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## 4 REFERENCES

- Anchor QEA and Integral, 2010. Final Remedial Investigation/Feasibility Study Work Plan, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Prepared by Anchor QEA, LLC (Ocean Springs, MS) and Integral Consulting Inc. (Seattle, WA). November 2010.
- Rifai, H., 2008. Total Maximum Daily Loads for PCBs in the Houston Ship Channel System. Segments 0901, 1001, 1005, 1006, 1007, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421. Quality Assurance Project Plan, Expedited Amendment Request #1. Prepared for Texas Commission on Environmental Quality. Prepared by H. Rifai, University of Houston Project Manager, University of Houston (Houston, TX). June 17, 2008.
- Rifai, H., 2009. Total Maximum Daily Loads for PCBs in the Houston Ship Channel System. Segments 0901, 1001, 1005, 1006, 1007, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421. Quality Assurance Project Plan, Revision 1. Prepared for Texas Commission on Environmental Quality. Prepared by H. Rifai, University of Houston Project Manager, University of Houston (Houston, TX). April 30, 2009.
- University of Houston and Parsons, 2009. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-22. Quarterly Report No. 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:  
<http://www.tceq.texas.gov/assets/public/implementation/water/tmdl/78hscpcbs/78-2009marchquarterly.pdf>.
- University of Houston and Parsons, 2010. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-29. Quarterly Report No. 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:  
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- USEPA, 2003. Method 1668, Revision A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS. EPA 821-R-07-004. U.S. Environmental

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Protection Agency, Office of Water, Office of Science and Technology, Engineering  
and Analysis Division (4303T), Washington, DC. August 2003.

**Table 1**  
**2008-2009 TMDL Tissue Samples**

<b>Sample Delivery Group</b>	<b>Sample Date</b>	<b>Integral Concatenated Sample ID</b>	<b>Integral Database Sample ID</b>	<b>Data Verification Report Sample ID</b>
A845862	4/22/2008	080422hcf11280	11280-F1-1	11280-F1-1-TISSUE
A845862	4/22/2008	080422bcf11287	11287-F1-1	11287-F1-1-TISSUE
A845862	4/29/2008	080429hcf11270	11270-F1-1	11270-F1-1-TISSUE
A845862	4/29/2008	080429spt11270	11270-F2-1	11270-F2-1-TISSUE
A845862	4/29/2008	080429hcf11274	11274-F1-1	11274-F1-1-TISSUE
A845862	4/29/2008	080429hcf13338	13338-F1-1	13338-F1-1-TISSUE
A845862	4/29/2008	080429spt13338	13338-F2-1	13338-F2-1-TISSUE
A860731	4/30/2008	080430hcf15936-dup	15936-F1-1-DUP	15936-F1-1-DUP-TISSUE
A860731	4/30/2008	080430hcf15936	15936-F1-1	15936-F1-1-TISSUE
A845862	4/30/2008	080430hcf15979-dup	15979-F1-1-DUP	15979-F1-1-DUP-TISSUE
A845862	4/30/2008	080430hcf15979	15979-F1-1	15979-F1-1-TISSUE
A845862	5/1/2008	080501hcf11264	11264-F1-1	11264-F1-1-TISSUE
A845862	5/1/2008	080501spt11264	11264-F2-1	11264-F2-1-TISSUE
A845862	5/1/2008	080501bcf16622	16622-F1-1	16622-F1-1-TISSUE
A860731	5/2/2008	080502hcf11193	11193-F1-1	11193-F1-1-TISSUE
A856461	5/28/2008	080528hcf13363-dup	13363-F1-1-DUP	13363-F1-1-DUP-TISSUE
A856461	5/28/2008	080528hcf13363	13363-F1-1	13363-F1-1-TISSUE
A860731	5/28/2008	080528spt13363	13363-F2-1	13363-F2-1-TISSUE
A860731	5/28/2008	080528hcf14560	14560-F1-1	14560-F1-1-TISSUE
A856461	5/28/2008	080528ckr14560	14560-F2-1	14560-F2-1-TISSUE
A860731	5/28/2008	080528spt14560	14560-F3-1	14560-F3-1-TISSUE
A860731	5/28/2008	080528hcf16213	16213-F1-1	16213-F1-1-TISSUE
A860731	5/28/2008	080528ckr16213	16213-F2-1	16213-F2-1
A856461	5/29/2008	080529hcf11252	11252-F1-1	11252-F1-1-TISSUE
A856461	5/29/2008	080529hcf16499	16499-F1-1	16499-F1-1-TISSUE
A856461	5/29/2008	080529hcf16618	16618-F1-1	16618-F1-1-TISSUE
A856461	5/29/2008	080529spt16618	16618-F2-1	16618-F2-1-TISSUE
A860731	5/30/2008	080530hcf11258-dup	11258-F1-1-DUP	11258-F1-1-DUP-TISSUE
A860731	5/30/2008	080530hcf11258	11258-F1-1	11258-F1-1-TISSUE
A860731	5/30/2008	080530hcf13342	13342-F1-1	13342-F1-1-TISSUE
A860731	5/30/2008	080530hcf13355	13355-F1-1	13355-F1-1-TISSUE
A860731	6/3/2008	080603ckr11258	11258-F2-1	11258-F2-1-TISSUE
A860731	6/3/2008	080603bcf11292	11292-F1-1	11292-F1-1
A860731	6/3/2008	080603ccf11347	11347-F1-1	11347-F1-1-TISSUE

**Table 1**  
**2008-2009 TMDL Tissue Samples**

<b>Sample Delivery Group</b>	<b>Sample Date</b>	<b>Integral Concatenated Sample ID</b>	<b>Integral Database Sample ID</b>	<b>Data Verification Report Sample ID</b>
A860731	6/3/2008	080603hcf13344	13344-F1-1	13344-F1-1-TISSUE
A860731	6/3/2008	080603hcf15301	15301-F1-1	15301-F1-1-TISSUE
A860731	6/4/2008	080604bcf11132	11132-F1-1	11132-F1-1-TISSUE
A860731	6/4/2008	080604hcf11261	11261-F1-1	11261-F1-1-TISSUE
A860731	6/4/2008	080604hcf11262	11262-F1-1	11262-F1-1-TISSUE
A860731	6/4/2008	080604ckr11262	11262-F2-1	11262-F2-1-TISSUE
A860731	6/4/2008	080604ckr13355	13355-F2-1	13355-F2-1-TISSUE
A892224	8/12/2008	080812ckr11252	11252-F2-1	11252-F2-1-TISSUE
A892224	8/12/2008	080812ckr13342	13342-F2-1	13342-F2-1-TISSUE
A892224	8/13/2008	080813ckr11193	11193-F2-1	11193-F2-1-TISSUE
A892224	8/13/2008	080813ckr13344	13344-F2-1	13344-F2-1-TISSUE
A892224	8/14/2008	080814ckr15301	15301-F2-1	15301-F2-1-TISSUE
A892224	8/15/2008	080815ckr11261	11261-F2-1	11261-F2-1-TISSUE
A892224	8/15/2008	080815ckr11280	11280-F2-1	11280-F2-1-TISSUE
A892224	8/15/2008	080815ckr15936	15936-F2-1	15936-F2-1-TISSUE
A892224	8/15/2008	080815ckr16499	16499-F2-1	16499-F2-1-TISSUE
1096012	5/5/2009	090505hcf11252	11252-F1-2	11252-F1-2
1096013	5/5/2009	090505hcf11252-dup	11252-F1-2-DUP	11252-F1-2-DUP
1096013	5/5/2009	090505ckr11252	11252-F2-2	11252-F2-2
1096012	5/7/2009	090507hcf13338	13338-F1-2	13338-F1-2
1096013	5/7/2009	090507hcf14560	14560-F1-2	14560-F1-2
1096010	5/7/2009	090507hcf16499	16499-F1-2	16499-F1-2
1096012	5/18/2009	090518hcf11258	11258-F1-2	11258-F1-2
1096010	5/18/2009	090518ckr11258	11258-F2-2	11258-F2-2
1096012	5/18/2009	090518ckr13338	13338-F2-2	13338-F2-2
1096013	5/18/2009	090518hcf13342	13342-F1-2	13342-F1-2
1096013	5/18/2009	090518ckr13342	13342-F2-2	13342-F2-2
1096012	5/18/2009	090518ckr16499	16499-F2-2	16499-F2-2
1096010	5/18/2009	090518hcf16618	16618-F1-2	16618-F1-2
1096013	5/18/2009	090518ckr16618	16618-F2-2	16618-F2-2
1096012	5/19/2009	090519hcf13344	13344-F1-2	13344-F1-2
1096010	5/19/2009	090519ckr13344	13344-F2-2B	13344-F2-2B
1099534	5/20/2009	090520ccf11132	11132-F1-2	11132-F1-2
1096010	5/21/2009	090521bcf11193	11193-F1-2	11193-F1-2
1096010	5/21/2009	090521ckr11193	11193-F2-2	11193-F2-2
1096012	5/21/2009	090521hcf11193	11193-F3-2	11193-F3-2
1096010	5/21/2009	090521hcf11193-dup	11193-F3-2-DUP	11193-F3-2-DUP

**Table 1**  
**2008-2009 TMDL Tissue Samples**

<b>Sample Delivery Group</b>	<b>Sample Date</b>	<b>Integral Concatenated Sample ID</b>	<b>Integral Database Sample ID</b>	<b>Data Verification Report Sample ID</b>
1097359	5/27/2009	090527hcf11270	11270-F1-2	11270-F1-2-UHDUP
1097359	5/27/2009	090527hcf15301	15301-F1-2	15301-F1-2-UHDUP
1097359	5/27/2009	090527hcf15936	15936-F1-2	15936-F1-2-UHDUP
1097103	5/27/2009	090527ckr15936	15936-F2-2	15936-F2-2-UHDUP
1097103	5/27/2009	090527hcf15979	15979-F1-2	15979-F1-2-UHDUP
1097103	5/28/2009	090528hcf13355	13355-F1-2	13355-F1-2-UHDUP
1097103	5/28/2009	090528ckr13355	13355-F2-2	13355-F2-2-UHDUP
1097103	5/28/2009	090528spt13355	13355-F3-2	13355-F3-2-UHDUP
1097103	5/28/2009	090528hcf13363	13363-F1-2	13363-F1-2-UHDUP
1098568	5/28/2009	090528ckr13363	13363-F2-2	13363-F2-2-AC
1097103	5/29/2009	090529hcf11264	11264-F1-2	11264-F1-2-UHDUP
1097359	5/29/2009	090529ckr11264	11264-F2-2	11264-F2-2-UHDUP
1098566	5/29/2009	090529ckr11280	11280-F2-2	11280-F2-2
1098566	5/29/2009	090529spt13363	13363-F2-2	13363-F2-2-ST
1098566	5/29/2009	090529spt13363-dup	13363-F2-2-DUP	13363-F2-2-ST-DUP
1098568	6/9/2009	090609hcf11261	11261-F1-2	11261-F1-2
1098566	6/9/2009	090609ckr11261	11261-F2-2	11261-F2-2
1098568	6/9/2009	090609hcf11262	11262-F1-2	11262-F1-2
1098566	6/9/2009	090609hcf11262-dup	11262-F1-2-DUP	11262-F1-2-DUP
1098568	6/9/2009	090609ckr11262	11262-F2-2	11262-F2-2
1099532	6/9/2009	090609bcf11274	11274-F1-2	11274-F1-2
1099532	6/10/2009	090610hcf11280	11280-F1-2	11280-F1-2
1098568	6/10/2009	090610bcf11292	11292-F1-2	11292-F1-2
1099533	6/10/2009	090610bcf11292-dup	11292-F1-2-DUP	11292-F1-2-DUP
1099532	6/12/2009	090612bcf11287	11287-F1-2	11287-F1-2
1099532	6/12/2009	090612ccf11347	11347-F1-2	11347-F1-2
1099534	6/17/2009	090617rdm15979	15979-F2-2	15979-F2-2
1099533	6/18/2009	090618hcf11265	11265-F1-2	11265-F1-2
1099533	6/18/2009	090618hcf11265-dup	11265-F1-2-DUP	11265-F1-2-DUP
1099533	6/18/2009	090618bcf16622	16622-F1-2	16622-F1-2
1099533	6/19/2009	090619hcf18322	18322-F1-2	18322-F1-2
1099532	6/24/2009	090624bcf11288	11288-F1-2	11288-F1-2
1099534	6/25/2009	090625hcf11271	11271-F1-2	11271-F1-2
1099532	7/15/2009	090715hcf17149	17149-F1-2	17149-F1-2

## **DATA VERIFICATION SUMMARY REPORT**

**for**

**PCBs in**

**FISH SAMPLES COLLECTED IN THE**

**HOUSTON SHIP CHANNEL SYSTEM**

**(Segments 2426, 2436, 2438, and 2421)**

**HOUSTON, TEXAS**

Data Verifier: Sandra de las Fuentes (Parsons - Austin, TX)

### **INTRODUCTION**

The following data verification summary report covers analysis of environmental samples, including forty-six (46) fish samples, four (4) field duplicate samples and three (3) blank samples collected from the Houston Ship Channel System in Houston Texas over the three month period between April 22, 2008 and August 15, 2008. The samples were analyzed for Polychlorinated Biphenyls (PCBs) as congeners and percent lipid content following laboratory Sample Delivery Group (SDG)

**A845862, A856461, A892224 and A860731 (4 sets)**

All samples were collected by the University of Houston and Parsons following the procedures described in the QAPP. All analyses were performed by Maxxam Analytical Inc. in Burlington, Canada following procedures outlined in the QAPP and Method 1668A for PCB congeners and an "In-House" Method for % Lipid Content.

### **EVALUATION CRITERIA**

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data (EPA 1994). Information reviewed in the data packages include sample results; the laboratory quality control results; instrument calibrations; blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field

duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results. The analyses and findings presented in this report are based on the reviewed information, and meeting guidelines in the QAPP (with the exceptions noted below).

## POLYCHLORINATED BIPHENYLS

### General

The SDGs included in this report contained the samples listed in Table 1 and analyzed for PCBs. The PCBs analyses were performed using USEPA Method 1668A (lab method: BRL SOP-00408). All samples for this SDG were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected were prepared and analyzed within the holding times required by the method.

**Table 1: Data Packages, Sample IDs and Collection Dates and Times**

Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *	SDG
15979-F1-1-TISSUE	4/30/2008 0:00	6/9/2008 0:00	40.00	Y	A845862
15979-F1-1-DUP-TISSUE	4/30/2008 0:00	6/9/2008 0:00	40.00	Y	
11264-F1-1-TISSUE	5/1/2008 0:00	6/9/2008 0:00	39.00	Y	
13338-F1-1-TISSUE	4/29/2008 0:00	6/9/2008 0:00	41.00	Y	
11274-F1-1-TISSUE	4/29/2008 0:00	6/9/2008 0:00	41.00	Y	
13338-F2-1-TISSUE	4/30/2008 0:00	6/9/2008 0:00	40.00	Y	
11264-F2-1-TISSUE	5/1/2008 0:00	6/9/2008 0:00	39.00	Y	
16622-F1-1-TISSUE	5/1/2008 0:00	6/9/2008 0:00	39.00	Y	
11270-F2-1-TISSUE	4/29/2008 0:00	6/9/2008 0:00	41.00	Y	
11270-F1-1-TISSUE	4/29/2008 0:00	6/9/2008 0:00	41.00	Y	
11280-F1-1-TISSUE	4/22/2008 0:00	6/9/2008 0:00	48.00	Y	
11287-F1-1-TISSUE	4/22/2008 0:00	6/9/2008 0:00	48.00	Y	
13363-F1-1-DUP-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	A856461
14560-F2-1-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	
13363-F1-1-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	
16618-F2-1-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	
16618-F1-1-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	
16499-F1-1-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	
11252-F1-1-TISSUE	5/29/2008 0:00	9/12/2008 0:00	106.00	Y	
11292-F1-1	6/3/2008 0:00	9/18/2008 0:00	107.00	Y	A860731
BLANK-B-F2-1	6/5/2008 0:00	9/18/2008 0:00	105.00	Y	
BLANK-A-F2-1	6/5/2008 0:00	9/18/2008 0:00	105.00	Y	
BLANK-C-F1-1	6/5/2008 0:00	9/18/2008 0:00	105.00	Y	

Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *	SDG
11262-F1-1-TISSUE	6/4/2008 0:00	10/2/2008 0:00	120.00	Y	A860731
15936-F1-1-DUP-TISSUE	4/30/2008 0:00	10/3/2008 0:00	156.00	Y	
14560-F1-1-TISSUE	5/28/2008 0:00	10/3/2008 0:00	128.00	Y	
13344-F1-1-TISSUE	5/30/2008 0:00	10/3/2008 0:00	126.00	Y	
15301-F1-1-TISSUE	5/30/2008 0:00	10/3/2008 0:00	126.00	Y	
16213-F1-1-TISSUE	5/28/2008 0:00	10/3/2008 0:00	128.00	Y	
11193-F1-1-TISSUE	5/2/2008 0:00	10/3/2008 0:00	154.00	Y	
15936-F1-1-TISSUE	4/30/2008 0:00	10/3/2008 0:00	156.00	Y	
11258-F1-1-TISSUE	5/30/2008 0:00	10/3/2008 0:00	126.00	Y	
11258-F1-1-DUP-TISSUE	5/30/2008 0:00	10/6/2008 0:00	129.00	Y	
13342-F1-1-TISSUE	5/30/2008 0:00	10/6/2008 0:00	129.00	Y	
11261-F1-1-TISSUE	6/1/2008 0:00	10/6/2008 0:00	127.00	Y	
11347-F1-1-TISSUE	6/3/2008 0:00	10/6/2008 0:00	125.00	Y	
11132-F1-1-TISSUE	6/4/2008 0:00	10/6/2008 0:00	124.00	Y	
14560-F2-1-TISSUE	5/28/2008 0:00	9/19/2008 0:00	114.00	Y	A860731
13363-F2-1-TISSUE	5/28/2008 0:00	9/19/2008 0:00	114.00	Y	
11262-F2-1-TISSUE	6/4/2008 0:00	9/19/2008 0:00	107.00	Y	
13355-F2-1-TISSUE	6/4/2008 0:00	9/19/2008 0:00	107.00	Y	
11258-F2-1-TISSUE	6/3/2008 0:00	9/19/2008 0:00	108.00	Y	
13355-F1-1-TISSUE	5/30/2008 0:00	9/19/2008 0:00	112.00	Y	A892224
11280-F2-1-TISSUE	8/15/2008 0:00	10/8/2008 0:00	54.00	Y	
11261-F2-1-TISSUE	8/15/2008 0:00	10/8/2008 0:00	54.00	Y	
15936-F2-1-TISSUE	8/15/2008 0:00	10/9/2008 0:00	55.00	Y	
16499-F2-1-TISSUE	8/15/2008 0:00	10/9/2008 0:00	55.00	Y	
11252-F2-1-TISSUE	8/12/2008 0:00	10/9/2008 0:00	58.00	Y	
15301-F2-1-TISSUE	8/14/2008 0:00	10/9/2008 0:00	56.00	Y	
11193-F2-1-TISSUE	8/13/2008 0:00	10/9/2008 0:00	57.00	Y	
13342-F2-1-TISSUE	8/12/2008 0:00	10/9/2008 0:00	58.00	Y	
16213-F2-1	5/28/2008 0:00	10/8/2008 0:00	133.00	Y	A860731
13344-F2-1-TISSUE	8/13/2008 0:00	10/30/2008 0:00	78.00	Y	A892224

### Accuracy

Accuracy was evaluated using the %R results for the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes.

The BS, LOQ and labeled compound spike recoveries %Rs were within method acceptance criteria, except for the congeners listed in "PCB\_QC\_Fish\_UH" worksheet "PCB Fish Flags". All LOQ failures are flagged "Q", blank spike failures are flagged

“S” and labeled compound spike recovery failures are flagged “R”. All associated congeners are flagged according to the QC failure type.

### **Precision**

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results. The following samples were collected and analyzed in duplicate for field duplicate QC purposes: 15979-F1-Tissue (collected 4/30/08), 13363-F1-1-Tissue (collected 5/29/08), 15936-F1-1-Tissue (collected 4/30/08), and 11258-F1-1-Tissue (collected 5/30/08). All field duplicate results were within QAPP tolerance except for the congeners listed in “PCB\_QC\_Fish\_UH” worksheet “PCB Fish Flags”. Both the parent and field duplicate samples were flagged “F” as estimated due to the out of tolerance % RPD. All associated congeners, that weren’t previously flagged “J”, “B” or “U” by the lab, were flagged as estimated (“F”) by the data verifier.

Lab duplicates of fish analyses were not possible due to insufficient media.

### **Representativeness**

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- \* Comparing the chain-of-custody procedures to those described in the QAPP;
- \* Evaluating holding times; and
- \* Examining method blanks for contamination of samples during analysis.

The samples in this SDG were collected and analyzed following the QAPP, COC and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis.

All initial calibration criteria were met.

All continuing calibration criteria (BS) were met.

All LOQ standard criteria were met, with the exception of those listed in the accuracy table.

There was at least one method blank analyzed with each batch associated with the PCBs analyses in each SDG. The method blanks had many PCBs of concern above the RLs. The sample results that were less than five (5) times the amount found in the blank were “B” flagged for having blank contamination.

### **Completeness**

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

No reported results for samples in this SDG have been rejected or invalidated. The completeness for this SDG is 100% compared to the minimum acceptance limit of 90%.

<b>Flag Key:</b>
H = Holding time exceedance
I = Ion ration failure
F = Field dup exceedance
L = Lab dup exceedance
S = Blank spike or lab control spike exceedance
Q = Limit of Quantitation (LOQ) exceedance
R = Surrogate/Internal Standard exceedance
J = Estimated by lab
U = Non-detected above MDL
B = Blank Contamination

**DATA VERIFICATION SUMMARY REPORT**  
**FOR PCBS IN FISH SAMPLES COLLECTED IN THE**  
**HOUSTON SHIP CHANNEL SYSTEM**

**(Segments 0901, 1001, 1005, 1006, 1007, 2420, 2429,  
2428, 2427, 2426, 2436, 2438, and 2421)**

**HOUSTON, TEXAS**

Data Verifier: Sandra de las Fuentes (Parsons - Austin, TX)

**INTRODUCTION**

The following data verification summary report covers analysis of environmental samples, including Fifty-eight (58) fish samples and six (6) field duplicate samples collected from the Houston Ship Channel System in Houston Texas over a two month between May 5, 2009 and June 25, 2009. The samples were analyzed for Polychlorinated Biphenyls (PCBs) as congeners and percent lipid content following laboratory Sample Delivery Group (SDG)

**1096010, 1096012, 1096013, 1097359, 1097103, 1098566, 1098568, 1099532, 1099533,  
and 1099534.**

All samples were collected by the University of Houston and Parsons following the procedures described in the QAPP. All analyses were performed by Pace Analytical Services, Inc. in Minneapolis, Minnesota, following procedures outlined in the QAPP and Method 1668A for PCB congeners and an "In-House" Method for % Lipid Content.

**EVALUATION CRITERIA**

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data (EPA 1994). Information reviewed in the data packages include sample results; the laboratory quality control results; instrument calibrations; blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results. The analyses and findings presented in this report are based on the reviewed information, and meeting guidelines in the QAPP (with the exceptions noted below).

Note: Lipid content has been reviewed and meets QAPP guidelines.

## POLYCHLORINATED BIPHENYLS

### General

The SDGs included in this report contained the samples listed in Table 1 and analyzed for PCBs. The PCBs analyses were performed using USEPA Method 1668A. All samples for this SDG were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected were prepared and analyzed within the holding times required by the method.

**Table 1: Data Packages, Sample IDs and Collection Dates and Times**

					Meet DQO for Holding Time
1096010	16618-F1-2	05/18/09	06/19/2009	32	Y
	11193-F3-2-DUP	05/21/09	06/20/2009	30	Y
	16499-F1-2	05/7/09	06/20/2009	44	Y
	11193-F2-2	05/21/09	06/20/2009	30	Y
	11193-F1-2	05/21/09	06/19/2009	29	Y
	13344-F2-2B	05/19/09	06/20/2009	32	Y
	11258-F2-2	05/18/09	06/20/2009	33	Y
1096012	11193-F3-2	05/21/09	06/20/2009	30	Y
	16499-F2-2	05/18/09	06/21/2009	34	Y
	13338-F1-2	05/7/09	06/20/2009	44	Y
	13344-F1-2	05/19/09	06/20/2009	32	Y
	13338-F2-2	05/18/09	06/20/2009	33	Y
	11252-F1-2	05/5/09	06/20/2009	46	Y
	11258-F1-2	05/18/09	06/20/2009	33	Y
1096013	16618-F2-2	05/18/09	06/21/2009	34	Y
	14560-F1-2	05/7/09	06/21/2009	45	Y
	13342-F2-2	05/18/09	06/21/2009	34	Y
	11252-F1-2-DUP	05/5/09	06/21/2009	47	Y
	11252-F2-2	05/5/09	06/21/2009	47	Y
	13342-F1-2	05/18/09	06/21/2009	34	Y
1097359	11264-F2-2-UHDUP	05/29/09	06/29/2009	31	Y
	11270-F1-2-UHDUP	05/27/09	06/29/2009	33	Y
	15301-F1-2-UHDUP	05/27/09	06/29/2009	33	Y
	15936-F1-2-UHDUP	05/27/09	06/28/2009	32	Y
1097103	11264-F1-2-UHDUP	05/29/09	06/27/2009	29	Y
	13355-F1-2-UHDUP	05/28/09	06/28/2009	31	Y
	13355-F2-2-UHDUP	05/28/09	06/27/2009	30	Y
	13355-F3-2-UHDUP	05/28/09	07/02/2009	35	Y
	13363-F1-2-UHDUP	05/28/09	06/27/2009	30	Y
	15936-F2-2-UHDUP	05/27/09	06/27/2009	31	Y
	15979-F1-2-UHDUP	05/27/09	06/28/2009	32	Y
1098566	13363-F2-2-ST	05/29/09	07/20/2009	52	Y

					Meet DQO for Holding Time
	11262-F1-2-DUP	06/9/09	07/20/2009	41	Y
	11261-F2-2	06/9/09	07/20/2009	41	Y
	11280-F2-2	05/29/09	07/20/2009	52	Y
	13363-F2-2-ST-DUP	05/29/09	07/27/2009	59	Y
1098568	11262-F2-2	06/9/09	07/27/2009	48	Y
	11292-F1-2	06/10/09	07/27/2009	47	Y
	13363-F2-2-AC	05/28/09	07/26/2009	59	Y
	11261-F1-2	06/9/09	07/26/2009	47	Y
	11262-F1-2	06/9/09	07/26/2009	47	Y
1099532	11274-F1-2	06/19/09	07/29/2009	40	Y
	11287-F1-2	06/12/09	07/29/2009	47	Y
	11347-F1-2	06/12/09	07/29/2009	47	Y
	17149-F1-2	07/15/09	07/29/2009	14	Y
	11280-F1-2	06/10/09	07/29/2009	49	Y
	11288-F1-2	06/24/09	07/29/2009	35	Y
1099533	11265-F1-2-DUP	06/19/2009	07/30/2009	41	Y
	18322-F1-2	06/19/2009	07/30/2009	41	Y
	11265-F1-2	06/18/2009	07/30/2009	42	Y
	BLANKA-F2-2	06/18/2009	07/30/2009	42	Y
	16622-F1-2	06/18/2009	07/30/2009	42	Y
	11292-F1-2-DUP	06/10/2009	07/30/2009	50	Y
1099534	11132-F1-2	05/20/2009	07/30/2009	71	Y
	11271-F1-2	06/25/2009	07/30/2009	35	Y
	15979-F2-2	06/17/2009	07/30/2009	43	Y
	BLANKB-F2-2	06/18/2009	07/30/2009	42	Y
	BLANKC-F2-2	06/18/2009	07/30/2009	42	Y

### Accuracy

Accuracy was evaluated using the %R results for the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes.

The BS, LOQ and labeled compound spike recoveries %Rs were within method acceptance criteria, except for the congeners listed in "PCB\_QC\_Fish\_Pace\_UH\_0910(P2)" worksheet "PCB Fish Flags". All LOQ failures are flagged "Q", blank spike failures are flagged "S", and labeled compound spike recovery failures are flagged "R". All associated congeners are flagged according to the QC failure type.

### Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results. The following samples were collected and

analyzed in duplicate for field duplicate QC purposes: 11193-F3-2 (collected 5/21/09), 11252-F1-2 (collected 5/5/09), 13363-F2-2 (collected 5/29/09), 11262-F1-2 (collected 6/9/09), 11292-F1-2 (collected 6/10/09), and 11265-F1-2 (collected 6/19/09). All field duplicate results were within QAPP tolerance except for the congeners listed in "PCB\_QC\_Fish\_Pace\_UH\_2009(P2)" worksheet "PCB Fish Flags". Both the parent and field duplicate samples were flagged "F" as estimated due to the out of tolerance % RPD. All associated congeners, that weren't previously flagged "J", "B" or "U" by the lab, were flagged as estimated ("F") by the data verifier.

The overall frequency of LD and FD is as follows:

QC Frequency for PCB Fish Samples						Frequency of LD
1096010	6	1	6	0	17%	0%
1096012	7	0	7	0	0%	0%
1096013	5	1	5	0	20%	0%
1097359	4	0	4	0	0%	0%
1097103	7	0	7	0	0%	0%
1098566	8	2	8	0	25%	0%
1098568						
1099532	6	0	6	0	0%	0%
1099533	4	2	6	0	50%	0%
1099534	5	0	5	0	0%	0%
Overall Frequency					11.5%	0.0%

The overall frequency met the required criteria for FD of 5%. Laboratory duplicates were not possible for these matrices due to insufficient media. An "F" flag was applied to the parent and duplicate congeners that was greater than 50% RPD.

### Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- \* Comparing the chain-of-custody procedures to those described in the QAPP;
- \* Evaluating holding times; and
- \* Examining method blanks for contamination of samples during analysis.

The samples in this SDG were collected and analyzed following the QAPP, COC and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis.

All initial calibration criteria were met.

All continuing calibration criteria (BS) were met.

All LOQ standard criteria were met, with the exception of those listed in "PCB\_QC\_Fish\_Pace\_UH\_2009(P2)" worksheet "PCB Fish Flags".

There was at least one method blank analyzed with each batch associated with the PCBs analyses in each SDG. The method blanks had some PCBs of concern above the RLs. The sample results that were less than five (5) times the amount found in the blank were "B" flagged for having blank contamination.

### **Completeness**

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

No reported results for samples in this SDG have been rejected or invalidated. The completeness for this SDG is 100% compared to the minimum acceptance limit of 90%.

### **COMPARABILITY**

All data was generated using contract-specific standard methods and reported with known data quality, type of analysis, units, etc.

### **DATA USABILITY**

All calculations were spot checked and verified. All data in this SDG are considered usable for the purposes of this project.

**ATTACHMENT A-2**  
**DATA VERIFICATION SUMMARY**  
**REPORT: SEDIMENT**

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## 1 INTRODUCTION

Sediment samples from location 11193 were collected on May 2, 2008 (two sediments) and May 20, 2009 (one sediment) in association with the Houston Ship Channel Dioxin Total Maximum Daily Load (TMDL) study (University of Houston and Parsons 2009, 2010). Sediment chemistry data used in the remedial investigation and feasibility study (RI/FS) but not collected specifically according to a U.S. Environmental Protection Agency (USEPA)-approved sampling and analysis plan must undergo a quality assurance (QA) review to ensure that the data are appropriate for use. This process is described in Section 3.1 of the RI/FS Work Plan (Anchor QEA and Integral 2010) and classifies the data into two categories—Category 1, data of known quality that are appropriate for use in decision making, and Category 2, data of unknown or suspect quality. Sediment data for polychlorinated biphenyl (PCB) congeners from the TMDL study were initially classified as Category 2 data because supporting QA data were not available. Two QA evaluations of the 2008 and 2009 sediment samples were obtained and this appendix documents a review of those QA evaluations to reclassify these data as Category 1. The samples reviewed are listed below:

SDG	Sample Date	Data Verification Report Sample ID
A845781	5/2/2008	11193-SE-1
A845781	5/2/2008	11193-SE-1-Dup
1096016	5/20/2009	11193-SE-2

## 2 EVALUATION

Data are classified into categories by evaluating the following factors:

- Traceability
- Comparability
- Sample integrity
- Potential measurement bias (i.e., accuracy, precision).

For data to be classified as Category 1, all of these factors must be known or supported by existing quality assurance/quality control (QA/QC) information including analytical methods, chain-of-custody, sample holding time, method blanks, matrix spike/matrix spike duplicates, laboratory control samples, replicates, and surrogates. The evaluation of these factors is documented in Appendix D-1 of the RI/FS Work Plan.

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Data verification summary reports for the subject sediment samples and prepared by Parsons of Austin, Texas, were obtained from the Texas Commission on Environmental Quality<sup>1</sup> to evaluate the data for the 2008–2009 TMDL sediments and are included as Attachments A2.1 and A2.2. The sections below discuss the QA/QC information documented in these reports. These data verification summary reports discuss samples from TMDL monitoring stations other than station 11193, which are not included in this memorandum. Some QA exceptions discussed in the attached reports do not apply to the samples discussed in this memorandum.

The following flags were assigned by Parsons personnel during their review of the 2008–2009 TMDL sediment data:

<b>Data Flags for 2008–2009 TMDL Sediment Data</b>	
F	Field duplicate exceedance
Q	Limit of quantitation exceedance

## **2.1 Analytical Method**

The 2008 sediment samples were analyzed by Maxxam Analytical Inc. of Burlington, Canada. The 2009 sediment samples were analyzed by Pace Analytical Services, Inc. of Minneapolis, MN. All samples were analyzed by USEPA Method 1668A (USEPA 2003), the analytical method specified in the TMDL study Quality Assurance Project Plan (QAPP; Rifai 2008, 2009).

## **2.2 Chain of Custody**

All chain of custody procedures followed those described in the QAPP for the TMDL study.

## **2.3 Holding Times**

The method specified analytical holding times of 1 year from sample collection to sample extraction and 1 year from sample extraction to sample analysis were met for all samples discussed in this memorandum.

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<sup>1</sup> <http://www.tceq.texas.gov/waterquality/tmdl/78-hsc-pcbs.html>

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## **2.4 Method Blanks**

The method blank frequency criteria (one for every 20 samples or one per extraction batch) set forth in the QAPP were met. The method blanks had many PCBs detected above the reporting limits. Sample results that were less than five times the amount found in the blank were "B" flagged to indicate the method blank contamination. No results were flagged based on method blank contamination.

## **2.5 Matrix Spikes/Matrix Spike Duplicates**

Recoveries in the matrix spike/matrix spike duplicates (MS/MSD) met the control limits (60 to 140 percent) specified in the QAPP, with the exception of analytes in parent samples having analyte concentrations greater than four times the amount spiked. No results were flagged based on MS/MSD recoveries.

## **2.6 Laboratory Control Samples**

Recoveries in the laboratory control samples met the control limits (50 to 150 percent) specified in the QAPP. No results were flagged based on laboratory control sample recoveries.

## **2.7 Replicates**

Precision was evaluated using the relative percent difference (RPD) obtained from the parent sample/field duplicate sample results. Most RPDs were within the control limit of less than 50 percent specified in the QAPP. When RPDs were greater than 50 percent, the results were flagged "F" as estimated by Parsons. Select PCB congeners associated with samples 11193-SE-1 and 11193-SE-1-DUP (collected in 2008) were "F" flagged by Parsons.

## **2.8 Labeled Compounds**

Recoveries of labeled compounds met the criteria specified in the analytical method (USEPA Method 1668A). No results were flagged based on labeled compound recoveries.

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## 2.9 Limit of Quantitation

Most of the 2008–2009 sediment sample results associated with location 11193 met the limits of quantitation (LOQ) specified in the QAPP. Select PCB congeners associated with sample 11193-SE-2 (collected in 2009) exceeded QAPP LOQs and were “Q” flagged by Parsons.

## 3 CONCLUSION

The samples discussed in this memo were collected and analyzed following the QAPP and analytical procedures. No reported results were rejected or invalidated. Based on the above review the PCB congener data for the samples discussed in this memorandum are acceptable and of known quality and can be considered to be Category 1 data.

## 4 REFERENCES

- Anchor QEA and Integral, 2010. Final Remedial Investigation/Feasibility Study Work Plan, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Prepared by Anchor QEA, LLC, Ocean Springs, MS, and Integral Consulting Inc., Seattle, WA. November 2010.
- Rifai, H., 2008. Total Maximum Daily Loads for PCBs in the Houston Ship Channel System. Segments 0901, 1001, 1005, 1006, 1007, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421. Quality Assurance Project Plan, Expedited Amendment Request #1. Prepared for Texas Commission on Environmental Quality. Prepared by H. Rifai, University of Houston Project Manager, University of Houston, Houston, TX. June 17, 2008.
- Rifai, H., 2009. Total Maximum Daily Loads for PCBs in the Houston Ship Channel System. Segments 0901, 1001, 1005, 1006, 1007, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421. Quality Assurance Project Plan, Revision 1. Prepared for Texas Commission on Environmental Quality. Prepared by H. Rifai, University of Houston Project Manager, University of Houston, Houston, TX. April 30, 2009.
- University of Houston and Parsons, 2009. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-22. Quarterly Report No. 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:

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<http://www.tceq.texas.gov/assets/public/implementation/water/tmdl/78hscpcbs/78-2009marchquarterly.pdf>.

University of Houston and Parsons, 2010. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-29. Quarterly Report No. 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:  
<http://www.tceq.texas.gov/assets/public/implementation/water/tmdl/78hscpcbs/78-2010marchquarterly.pdf>.

USEPA, 2003. Method 1668, Revision A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS. EPA 821-R-07-004. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division (4303T), Washington, DC. August 2003.

**DATA VERIFICATION SUMMARY REPORT**  
**for**  
**PCBs and TOC in**  
**SEDIMENT SAMPLES COLLECTED IN THE**  
**HOUSTON SHIP CHANNEL SYSTEM**  
**(Segments 2426, 2436, 2438, and 2421)**  
**HOUSTON, TEXAS**

Data Verifier: Sandra de las Fuentes (Parsons - Austin, TX)

**INTRODUCTION**

The following data verification summary report covers analysis of environmental sediment samples, including ninety (90) sediment samples and ten (10) field duplicate, collected from the Houston Ship Channel System in Houston Texas over the one month period between April 24, 2008 and July 13, 2008. The samples were analyzed for Polychlorinated Biphenyls (PCBs) as congeners and Total Organic Carbon (TOC) following laboratory Sample Delivery Groups (SDGs)

**A845781, A855832, A860731, A861230, A877854, A877902 (3 sets), A877812, and A884606**

All samples were collected by the University of Houston and Parsons following the procedures described in the QAPP. All analyses were performed by Maxxam Analytical Inc. in Burlington, Canada following procedures outlined in the QAPP and Method 1668A for PCB congeners. Maxxam Analytical Inc. sent the TOC samples to Maxxam Analytic Mississauga in Ontario, Canada for analysis following the LECO Combustion method.

**EVALUATION CRITERIA**

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data (EPA 1994). Information reviewed in the data packages include sample results; the laboratory quality control results; instrument calibrations; blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following

parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results. The analyses and findings presented in this report are based on the reviewed information, and meeting guidelines in the QAPP (with the exceptions noted below).

## POLYCHLORINATED BIPHENYLS

### General

The SDGs included in this report contained the samples listed in Table 1 and analyzed for PCBs. The PCBs analyses were performed using USEPA Method 1668A (lab method: BRL SOP-00408). All samples for this SDG were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected were prepared and analyzed within the holding times required by the method. Some sediment samples required dilution due to high PCBs and/or matrix interference.

**Table 1: Data Packages, Sample IDs and Collection Dates and Times**

SDG	Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *
A845781	13338-SE-1	4/24/2008 0:00	6/5/2008 0:00	42.00	Y
	11287-SE-1	4/28/2008 0:00	6/9/2008 0:00	42.00	Y
	11274-SE-1	4/28/2008 0:00	6/9/2008 0:00	42.00	Y
	11270-SE-1	4/29/2008 0:00	6/9/2008 0:00	41.00	Y
	15979-SE-1	4/30/2008 0:00	6/9/2008 0:00	40.00	Y
	16622-SE-1	5/1/2008 0:00	6/9/2008 0:00	39.00	Y
	11280-SE-1	4/30/2008 0:00	6/6/2008 0:00	37.00	Y
	11264-SE-1	5/2/2008 0:00	6/9/2008 0:00	38.00	Y
	11193-SE-1-Dup	5/2/2008 0:00	6/8/2008 0:00	37.00	Y
A855832	11193-SE-1	5/2/2008 0:00	6/9/2008 0:00	38.00	Y
	16213-SE-1-SOIL	5/27/2008 0:00	6/18/2008 0:00	22.00	Y
	11252-SE-1-SOIL	5/27/2008 0:00	6/18/2008 0:00	22.00	Y
	14560-SE-1-SOIL	5/27/2008 0:00	6/18/2008 0:00	22.00	Y
	13363-SE-1-SOIL	5/27/2008 0:00	6/18/2008 0:00	22.00	Y
	16499-SE-1-SOIL	5/27/2008 0:00	6/18/2008 0:00	22.00	Y
	16618-SE-1-SOIL	5/29/2008 0:00	6/18/2008 0:00	20.00	Y
A860731	13355-SE-1-SOIL	5/29/2008 0:00	6/18/2008 0:00	20.00	Y
	11347-SE-1	6/2/2008 0:00	7/10/2008 0:00	38.00	Y
	13344-SE-1	6/2/2008 0:00	7/10/2008 0:00	38.00	Y
	15301-SE-1	6/2/2008 0:00	7/10/2008 0:00	38.00	Y
	15301-SE-1-DUP	6/2/2008 0:00	7/10/2008 0:00	38.00	Y
	11258-SE-1	6/2/2008 0:00	7/30/2008 0:00	58.00	Y

SDG	Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *
	TRIP2-SE-1	6/4/2008 0:00	7/10/2008 0:00	36.00	Y
	TRIP1-SE-1	6/4/2008 0:00	7/10/2008 0:00	36.00	Y
	11132-SE-1	6/4/2008 0:00	7/10/2008 0:00	36.00	Y
	11261-SE-1	6/4/2008 0:00	7/10/2008 0:00	36.00	Y
	11262-SE-1	6/4/2008 0:00	7/10/2008 0:00	36.00	Y
	13342-SE-1	6/4/2008 0:00	7/10/2008 0:00	36.00	Y
A861230	11258-SE-1-DUP - SOIL	6/2/2008 0:00	7/10/2008 0:00	38.00	Y
	11292-SE-1	6/2/2008 0:00	7/10/2008 0:00	38.00	Y
A877854	C-001-Se-1	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-002-Se-1	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-003-Se-1	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-004-Se-1	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-004-Se-1-A	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-004-Se-1-B	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-004-Se-1-C	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-004-Se-1-D	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-004-Se-1-E	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-005-Se-1	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	C-006-Se-1	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	T-013-Se-1	7/15/2008 0:00	8/19/2008 0:00	35.00	Y
	T-014-Se-1	7/15/2008 0:00	7/30/2008 0:00	15.00	Y
	T-014-Se-1-Dup	7/15/2008 0:00	7/30/2008 0:00	15.00	Y
	T-015-Se-1	7/15/2008 0:00	7/30/2008 0:00	15.00	Y
	T-016-Se-1	7/15/2008 0:00	7/30/2008 0:00	15.00	Y
	ERS-Se-1	7/12/2008 0:00	7/30/2008 0:00	18.00	Y
	Trip1-Se-1-SI	7/14/2008 0:00	7/30/2008 0:00	16.00	Y
A877902	T-001-Se-1	7/10/2008 0:00	8/19/2008 0:00	40.00	Y
	T-001-Se-1-Dup	7/10/2008 0:00	8/19/2008 0:00	40.00	Y
	T-002-Se-1	7/10/2008 0:00	8/19/2008 0:00	40.00	Y
	T-003-Se-1	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-007-Se-1-C	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-007-Se-1-D	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-007-Se-1-E	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-008-Se-1	7/12/2008 0:00	8/19/2008 0:00	38.00	Y
	W-007-Se-1-A	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-001-Se-1	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-002-Se-1	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-002-Se-1-Dup	7/11/2008 0:00	8/19/2008 0:00	39.00	Y

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SDG	Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *
	W-003-Se-1	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-004-Se-1	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
	W-005-Se-1	7/11/2008 0:00	8/19/2008 0:00	39.00	Y
A877902	T004-SE-1	7/11/2008 0:00	9/17/2008 0:00	68.00	Y
	T005-SE-1	7/10/2008 0:00	9/17/2008 0:00	69.00	Y
	T006-SE-1	7/10/2008 0:00	9/17/2008 0:00	69.00	Y
	T007-SE-1	7/10/2008 0:00	9/17/2008 0:00	69.00	Y
	T008-SE-1	7/10/2008 0:00	9/17/2008 0:00	69.00	Y
	T009-SE-1	7/13/2008 0:00	9/17/2008 0:00	66.00	Y
	W007-SE-1	7/11/2008 0:00	9/17/2008 0:00	68.00	Y
A877812	E008-SE-1	7/9/2008 0:00	9/12/2008 0:00	65.00	Y
	E009-SE-1	7/9/2008 0:00	9/13/2008 0:00	66.00	Y
	E010-SE-1	7/9/2008 0:00	9/13/2008 0:00	66.00	Y
	E011-SE-1	7/9/2008 0:00	9/13/2008 0:00	66.00	Y
	E011-SE-1- DUP	7/9/2008 0:00	9/13/2008 0:00	66.00	Y
	E012-SE-1	7/13/2008 0:00	9/13/2008 0:00	62.00	Y
	E013-SE-1	7/13/2008 0:00	9/13/2008 0:00	62.00	Y
	E014-SE-1	7/13/2008 0:00	9/13/2008 0:00	62.00	Y
	E015-SE-1	7/13/2008 0:00	9/12/2008 0:00	61.00	Y
	E013-SE-1-A	7/13/2008 0:00	9/14/2008 0:00	63.00	Y
	E013-SE-1-A-DUP	7/13/2008 0:00	9/14/2008 0:00	63.00	Y
	E013-SE-1-B-DUP	7/13/2008 0:00	9/14/2008 0:00	63.00	Y
	E013-SE-1-B	7/13/2008 0:00	9/14/2008 0:00	63.00	Y
	E013-SE-1-C	7/13/2008 0:00	9/14/2008 0:00	63.00	Y
	E013-SE-1-D	7/13/2008 0:00	9/15/2008 0:00	64.00	Y
	E013-SE-1-E	7/13/2008 0:00	9/14/2008 0:00	63.00	Y
	T009-SE-1-DUP	7/13/2008 0:00	9/16/2008 0:00	65.00	Y
	T010-SE-1	7/13/2008 0:00	9/15/2008 0:00	64.00	Y
	T011-SE-1	7/13/2008 0:00	9/17/2008 0:00	66.00	Y
	T012-SE-1	7/13/2008 0:00	9/16/2008 0:00	65.00	Y
	E001-SE-1	7/8/2008 0:00	9/16/2008 0:00	70.00	Y
	E002-SE-1	7/8/2008 0:00	9/16/2008 0:00	70.00	Y
	E003-SE-1	7/8/2008 0:00	9/17/2008 0:00	71.00	Y
	E004-SE-1	7/8/2008 0:00	9/16/2008 0:00	70.00	Y
	E005-SE-1	7/8/2008 0:00	9/16/2008 0:00	70.00	Y
	E006-SE-1	7/9/2008 0:00	9/16/2008 0:00	69.00	Y
	E007-SE-1	7/9/2008 0:00	9/16/2008 0:00	69.00	Y

SDG	Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *
A884606	Trip2-Se-1-SI	7/29/2008 0:00	9/21/2008 0:00	54.00	Y
A877902	W006-SE-1	7/11/2008 0:00	9/21/2008 0:00	72.00	Y
	W007-SE-1-B	7/11/2008 0:00	9/21/2008 0:00	72.00	Y

### Accuracy

Accuracy was evaluated using the %R results for the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes.

The BS, LOQ and labeled compound spike recoveries %Rs were within method acceptance criteria, except for the congeners listed in “PCB\_QC\_Sed and Water\_UH” worksheet “PCB Sed Flags”. All LOQ failures are flagged “Q”, blank spike failures are flagged “S” and labeled compound spike recovery failures are flagged “R”. All associated congeners are flagged according to the QC failure type.

### Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results. The following samples were collected and analyzed in duplicate for field duplicate QC purposes: 11193-SE-1 (collected 5/2/08), 15301-SE-1 (collected 6/2/08), 11258-SE-1 (collected 6/2/08), T-014-SE-1 (collected 7/15/08), T-001-SE-1 (collected 7/10/08), W-002-SE-1 (collected 7/11/08), E-011-SE-1 (collected 7/9/08), E013-SE-1-A (collected 7/13/08), E013-SE-1-B (collected 7/13/08), and T009-SE-1 (collected 7/13/08).

All field duplicate results were within QAPP tolerance except for the congeners listed in “PCB\_QC\_Sed and Water\_UH” worksheet “PCB Sed Flags”. Both the parent and field duplicate samples were flagged “F” as estimated due to the out of tolerance % RPD. All associated congeners, that weren’t previously flagged “J”, “B” or “U” by the lab, were flagged as estimated (“F”) by the data verifier.

The following samples were analyzed in duplicate for lab duplicate QC purposes: 13338-SE-1, 11262-SE-1, C004-SE-1A, W001-SE-1, E014-SE-1, T009-SE-1. All lab duplicate results were within QAPP tolerance.

### Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- \* Comparing the chain-of-custody procedures to those described in the QAPP;
- \* Evaluating holding times; and

- \* Examining method blanks for contamination of samples during analysis.

The samples in this SDG were collected and analyzed following the QAPP, COC and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis.

All initial calibration criteria were met.

All continuing calibration criteria (BS) were met, with the exception of those listed in the accuracy table.

All LOQ standard criteria were met, with the exception of those listed in the accuracy table.

There was at least one method blank analyzed with each batch associated with the PCBs analyses in each SDG. The method blanks had many PCBs of concern above the RLs. The sample results that were less than five (5) times the amount found in the blank were “B” flagged for having blank contamination.

### Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

No reported results for samples in this SDG have been rejected or invalidated. The completeness for this SDG is 100% compared to the minimum acceptance limit of 90%.

<b>Flag Key:</b>
H = Holding time exceedance
I = Ion ration failure
F = Field dup exceedance
L = Lab dup exceedance
S = Blank spike or lab control spike exceedance
Q = Limit of Quantitation (LOQ) exceedance
R = Surrogate/Internal Standard exceedance
J = Estimated by lab
U = Non-detected above MDL
B = Blank Contamination

**TOTAL ORGANIC CARBON****General**

The SDGs included in this report contained the samples listed in Table 1 and analyzed for TOC. The TOC analyses were performed using LECO Combustion Method (lab method: CAM SOP-00468). All samples for this SDG were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected were prepared and analyzed within the holding times required by the method, with the exception of 13338 (collected 4/24/08).

**Table 1: Data Packages, Sample IDs and Collection Dates and Times**

<b>SDG</b>	<b>Sample ID</b>	<b>Sample Collected Date/Time</b>	<b>Sample Analyzed Date/Time</b>	<b>Holding Time (Days)</b>	<b>Meet DQO for Holding Time *</b>
<b>A845781</b>	13338-SE-1	4/24/2008 0:00	5/24/2008 0:00	30.00	N
	11287-SE-1	4/28/2008 0:00	5/24/2008 0:00	26.00	Y
	11274-SE-1	4/28/2008 0:00	5/24/2008 0:00	26.00	Y
	11270-SE-1	4/29/2008 0:00	5/24/2008 0:00	25.00	Y
	15979-SE-1	4/30/2008 0:00	5/24/2008 0:00	24.00	Y
	16622-SE-1	5/1/2008 0:00	5/24/2008 0:00	23.00	Y
	11280-SE-1	4/30/2008 0:00	5/24/2008 0:00	24.00	Y
	11264-SE-1	5/2/2008 0:00	5/24/2008 0:00	22.00	Y
	11193-SE-1-Dup	5/2/2008 0:00	5/24/2008 0:00	22.00	Y
	11193-SE-1	5/2/2008 0:00	5/24/2008 0:00	22.00	Y
<b>A855832</b>	16213-SE-1-SOIL	5/27/2008 0:00	6/11/2008 0:00	15.00	Y
	11252-SE-1-SOIL	5/27/2008 0:00	6/11/2008 0:00	15.00	Y
	14560-SE-1-SOIL	5/27/2008 0:00	6/11/2008 0:00	15.00	Y
	13363-SE-1-SOIL	5/27/2008 0:00	6/11/2008 0:00	15.00	Y
	16499-SE-1-SOIL	5/27/2008 0:00	6/11/2008 0:00	15.00	Y
	16618-SE-1-SOIL	5/29/2008 0:00	6/11/2008 0:00	13.00	Y
	13355-SE-1-SOIL	5/29/2008 0:00	6/11/2008 0:00	13.00	Y
<b>A860731</b>	13342-SE-1-SOIL	6/4/2008 0:00	6/17/2008 0:00	13.00	Y
	11262-SE-1-SOIL	6/4/2008 0:00	6/17/2008 0:00	13.00	Y
	11261-SE-1-SOIL	6/4/2008 0:00	6/17/2008 0:00	13.00	Y
	11132-SE-1-SOIL	6/4/2008 0:00	6/17/2008 0:00	13.00	Y
	TRIP1-SE-1-SOIL	6/4/2008 0:00	6/17/2008 0:00	13.00	Y
	TRIP2-SE-1-SOIL	6/4/2008 0:00	6/17/2008 0:00	13.00	Y
	11258-SE-1-SOIL	6/2/2008 0:00	6/17/2008 0:00	15.00	Y
	15301-SE-1-DUP-SOIL	6/2/2008 0:00	6/17/2008 0:00	15.00	Y
	15301-SE-1-SOIL	6/2/2008 0:00	6/17/2008 0:00	15.00	Y
	13344-SE-1-SOIL	6/2/2008 0:00	6/17/2008 0:00	15.00	Y
	11347-SE-1-SOIL	6/2/2008 0:00	6/17/2008 0:00	15.00	Y

*PCBs TMDL Project – Work Order# 582-6-70860-22 – Quarterly Report 2*

<b>SDG</b>	<b>Sample ID</b>	<b>Sample Collected Date/Time</b>	<b>Sample Analyzed Date/Time</b>	<b>Holding Time (Days)</b>	<b>Meet DQO for Holding Time *</b>
A861230	11292-SE-1	6/2/2008 0:00	6/17/2008 0:00	15.00	Y
	11258-SE-1-DUP	6/2/2008 0:00	6/17/2008 0:00	15.00	Y
A877812	T009-SE-1-DUP-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	T010-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	T011-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	T012-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	E001-SE-1-SOIL	7/8/2008 0:00	7/30/2008 0:00	22.00	Y
	E002-SE-1-SOIL	7/8/2008 0:00	7/30/2008 0:00	22.00	Y
	E003-SE-1-SOIL	7/8/2008 0:00	7/30/2008 0:00	22.00	Y
	E004-SE-1-SOIL	7/8/2008 0:00	7/30/2008 0:00	22.00	Y
	E005-SE-1-SOIL	7/8/2008 0:00	7/30/2008 0:00	22.00	Y
	E006-SE-1-SOIL	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E007-SE-1-SOIL	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E008-SE-1-SOIL	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E009-SE-1-SOIL	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E010-SE-1-SOIL	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E011-SE-1-SOIL	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E011-SE-1-SOIL-DUP	7/9/2008 0:00	7/30/2008 0:00	21.00	Y
	E012-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	E013-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	E014-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	E015-SE-1-SOIL	7/13/2008 0:00	7/30/2008 0:00	17.00	Y
	E013-SE-1-A-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
	E013-SE-1-A-DUP-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
	E013-SE-1-B-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
	E013-SE-1-B-DUP-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
	E013-SE-1-C-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
	E013-SE-1-D-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
	E013-SE-1-E-SOIL	7/13/2008 0:00	7/29/2008 0:00	16.00	Y
A877854	C001-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C002-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C003-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C004-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C005-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C006-SE-1-SOIL	7/13/2008 0:00	8/6/2008 0:00	24.00	Y
	C004-SE-1-A-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C004-SE-1-B-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C004-SE-1-C-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C004-SE-1-D-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	C004-SE-1-E-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	ERS-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	T014-SE-1-SOIL	7/15/2008 0:00	8/6/2008 0:00	22.00	Y

SDG	Sample ID	Sample Collected Date/Time	Sample Analyzed Date/Time	Holding Time (Days)	Meet DQO for Holding Time *
	T016-SE-1-SOIL	7/15/2008 0:00	8/6/2008 0:00	22.00	Y
	T014-SE-1-DUP-SOIL	7/15/2008 0:00	8/6/2008 0:00	22.00	Y
	TRIP1-SE-1-SOIL	7/14/2008 0:00	8/6/2008 0:00	23.00	Y
	T015-SE-1-SOIL	7/15/2008 0:00	8/6/2008 0:00	22.00	Y
	T013-SE-1-SOIL	7/15/2008 0:00	8/6/2008 0:00	22.00	Y
A877902	W007-SE-1-B-SOIL	7/11/2008 0:00	8/7/2008 0:00	27.00	Y
	W007-SE-1-C-SOIL	7/11/2008 0:00	8/7/2008 0:00	27.00	Y
	W007-SE-1-D-SOIL	7/11/2008 0:00	8/7/2008 0:00	27.00	Y
	T008-SE-1-SOIL	7/10/2008 0:00	8/7/2008 0:00	28.00	Y
	T009-SE-1-SOIL	7/13/2008 0:00	8/7/2008 0:00	25.00	Y
	W007-SE-1-SOIL	7/11/2008 0:00	8/7/2008 0:00	27.00	Y
	W001-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W002-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W002-SE-1-DUP-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W003-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W004-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W005-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W006-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W007-SE-1-A-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W007-SE-1-E-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	W008-SE-1-SOIL	7/12/2008 0:00	8/6/2008 0:00	25.00	Y
	T001-SE-1-SOIL	7/10/2008 0:00	8/6/2008 0:00	27.00	Y
	T001-SE-1-DUP-SOIL	7/10/2008 0:00	8/6/2008 0:00	27.00	Y
	T002-SE-1-SOIL	7/10/2008 0:00	8/6/2008 0:00	27.00	Y
	T003-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	T004-SE-1-SOIL	7/11/2008 0:00	8/6/2008 0:00	26.00	Y
	T005-SE-1-SOIL	7/10/2008 0:00	8/6/2008 0:00	27.00	Y
	T006-SE-1-SOIL	7/10/2008 0:00	8/6/2008 0:00	27.00	Y
	T007-SE-1-SOIL	7/10/2008 0:00	8/6/2008 0:00	27.00	Y
A884606	TRIP2-SE-1 - SOIL	7/29/2008 0:00	8/21/2008 0:00	23.00	Y

Sample 13338 (collected 4/24/08) was analyzed 2 day outside of holding time. This sample was flagged “H” for the minor exceedances of holding time for TOC.

### Accuracy

Accuracy was evaluated using the %R results for the blank spike samples (BS). The BS %Rs were within method acceptance criteria for all SDGs.

## Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results and the lab duplicate results. The following samples were collected and analyzed in duplicate for field duplicate QC purposes: 11193-SE-1 (collected 5/2/08), 15301-SE-1 (collected 6/2/08), 11258-SE-1 (collected 6/2/08), T-014-SE-1 (collected 7/15/08), T-001-SE-1 (collected 7/10/08), W-002-SE-1 (collected 7/11/08), E-011-SE-1 (collected 7/9/08), E013-SE-1-A (collected 7/13/08), E013-SE-1-B (collected 7/13/08), and T009-SE-1 (collected 7/13/08). All field duplicate results were within QAPP tolerance, except for the following:

Field Duplicate Results for TOC Samples							
SDG	Lab Batch #	Sample ID	Sample Date	TOC (mg/Kg)		RPD	Accept
				T1	T2		
A860731 & A861230	1538383	11258-SE-1-DUP	6/2/2008	9400	5100	59.3	N

Samples 11258-SE-1 and 11258-SE-1-Dup were flagged “F” for field duplicate %RPD exceedances.

The following samples were analyzed in duplicate for lab duplicate QC purposes: 13338-SE-1, 16213-SE-1, 13342-SE-1, 11258-SE-1-DUP, E005-SE-1, E013-SE-1-B, C001-SE-1, W001-SE-1, and TRIP2-SE-1.

All lab duplicate results were within QAPP tolerance, with the following exception:

## Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- \* Comparing the chain-of-custody procedures to those described in the QAPP;
- \* Evaluating holding times; and
- \* Examining method blanks for contamination of samples during analysis.

The samples in this SDG were collected and analyzed following the QAPP, COC and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis.

All initial calibration criteria were met.

All continuing calibration criteria (BS) were met, with the exception of those listed in the accuracy table.

There was at least one method blank analyzed with each batch associated with the TOC analyses in each SDG. The method blanks were below the RLs.

### Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

No reported results for samples in this SDG have been rejected or invalidated. The completeness for this SDG is 100% compared to the minimum acceptance limit of 90%.

<b>Flag Key:</b>
H = Holding time exceedance
I = Ion ration failure
F = Field dup exceedance
L = Lab dup exceedance
S = Blank spike or lab control spike exceedance
Q = Limit of Quantitation (LOQ) exceedance
R = Surrogate/Internal Standard exceedance
J = Estimated by lab
U = Non-detected above MDL
B = Blank Contamination

**DATA VERIFICATION SUMMARY REPORT**  
**FOR PCBS IN SEDIMENT SAMPLES COLLECTED IN THE**  
**HOUSTON SHIP CHANNEL SYSTEM**

**(Segments 0901, 1001, 1005, 1006, 1007, 2420, 2429,  
2428, 2427, 2426, 2436, 2438, and 2421)**

**HOUSTON, TEXAS**

Data Verifier: Sandra de las Fuentes (Parsons - Austin, TX)

**INTRODUCTION**

The following data verification summary report covers analysis of environmental sediment samples, including forty-two (42) sediment samples and four (4) field duplicate samples, collected from the Houston Ship Channel System in Houston Texas over the three month period between May 6, 2009 and August 12, 2009. The samples were analyzed for Polychlorinated Biphenyls (PCBs) as congeners following laboratory Sample Delivery Groups (SDGs)

**1094733, 1096016, 1096018, 1097888, 1097891, 1097894, 1097895, 1098517, 1099535,  
and 10110354.**

All samples were collected by the University of Houston and Parsons following the procedures described in the QAPP. All analyses were performed by Pace Analytical Services, Inc. in Minneapolis, Minnesota, following procedures outlined in the QAPP and Method 1668A for PCB congeners.

**EVALUATION CRITERIA**

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data (EPA 1994). Information reviewed in the data packages include sample results; the laboratory quality control results; instrument calibrations; blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results. The analyses and findings presented in this report are based on the reviewed information, and meeting guidelines in the QAPP (with the exceptions noted below).

## POLYCHLORINATED BIPHENYLS

### General

The SDGs included in this report contained the samples listed in Table 1 and analyzed for PCBs. The PCBs analyses were performed using USEPA Method 1668A. All samples for this SDG were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected were prepared and analyzed within the holding times required by the method. Some sediment samples required dilution due to high PCBs and/or matrix interference.

**Table 1: Data Packages, Sample IDs and Collection Dates and Times**

					Meet DQO for Holding Time *
1094733	13338-SE-2	5/6/2009	6/19/2009	44	Y
	13338-SE-2-DUP	5/6/2009	6/19/2009	44	Y
	16499-SE-2	5/6/2009	6/19/2009	44	Y
	11252-SE-2	5/6/2009	6/19/2009	44	Y
1096016	11258-SE-2	5/22/2009	6/18/2009	27	Y
	15301-SE-2	5/26/2009	6/18/2009	23	Y
	11270-SE-2-DUP	5/26/2009	6/18/2009	23	Y
	11193-SE-2	5/20/2009	6/22/2009	33	Y
	13344-SE-2	5/20/2009	6/21/2009	32	Y
	11261-SE-2	5/20/2009	6/18/2009	29	Y
	16618-SE-2	5/21/2009	6/19/2009	29	Y
	15936-SE-2	5/26/2009	6/18/2009	23	Y
1096018	16622-SE-2	5/21/2009	6/17/2009	27	Y
	11270-SE-2	5/26/2009	6/18/2009	23	Y
	15979-SE-2	5/26/2009	6/18/2009	23	Y
1097888	11264-SE-2	5/29/2009	7/1/2009	33	Y
	11280-SE-2	5/29/2009	07/10/2009	42	Y
	11274-SE-2	6/4/2009	07/01/2009	27	Y
	11292-SE-2	6/4/2009	07/01/2009	27	Y
	11287-SE-2	6/4/2009	07/10/2009	36	Y
	11287-SE-2-DUP	6/4/2009	07/10/2009	36	Y
	11262-SE-2	6/4/2009	07/01/2009	27	Y
1097891	TBD11-SE-2	6/10/2009	07/07/2009	27	Y
	TRIP1-SED-2	6/10/2009	07/07/2009	27	Y
1097894	11132-SE-2	6/17/2009	07/13/2009	26	Y
	18322-SE-2	6/18/2009	07/13/2009	25	Y
	11265-SE-2	6/12/2009	07/13/2009	31	Y
	11285-SE-2	6/12/2009	07/13/2009	31	Y
	ERB1-SE-2	6/18/2009	07/13/2009	25	Y
	11288-SE-2	6/12/2009	07/13/2009	31	Y
	11302-SE-2	6/10/2009	07/14/2009	34	Y

					Meet DQO for Holding Time *
1097895	TBD10-SE-2	6/12/2009	07/07/2009	25	Y
	18322-SE-2-DUP	6/18/2009	07/07/2009	19	Y
	TRIP2-SE-2	6/18/2009	7/8/2009	20	Y
1098517	11347-SE-2	6/29/2009	7/14/2009	15	Y
	11129-SE-2	6/26/2009	7/21/2009	25	Y
	20574-SE-2	6/26/2009	7/15/2009	19	Y
1099535	13342-Se-2	5/20/2009	09/04/2009	107	Y
	T002-Se-2	6/11/2009	09/04/2009	85	Y
	17149-Se-2	7/15/2009	09/04/2009	51	Y
10110354	18363-SE-2	8/10/2009	09/02/2009	23	Y
	TBD15-SE-2	8/12/2009	09/02/2009	21	Y

\* Holding time acceptance criteria for PCBs is less than 1 yr.

### Accuracy

Accuracy was evaluated using the %R results for the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes.

The BS, LOQ and labeled compound spike recoveries %Rs were within method acceptance criteria, except for the congeners listed in "PCB\_QC\_Sed\_Pace\_UH\_2009(P2)" worksheet "PCB Sed Flags". All LOQ failures are flagged "Q", blank spike failures are flagged "S" and labeled compound spike recovery failures are flagged "R". All associated congeners are flagged according to the QC failure type.

### Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results. The following samples were collected and analyzed in duplicate for field duplicate QC purposes: 13338-SE-2 (collected 5/6/09), 11270-SE-2 (collected 5/26/09), 11287-SE-2 (collected 6/4/09), and 18322-SE-2 (collected 6/18/09).

All field duplicate results were within QAPP tolerance except for the congeners listed in "PCB\_QC\_Sed\_Pace\_UH\_2009(P2)" worksheet "PCB Sed Flags". Both the parent and field duplicate samples were flagged "F" as estimated due to the out of tolerance % RPD. All associated congeners, that weren't previously flagged "J", "B" or "U" by the lab, were flagged as estimated ("F") by the data verifier.

The following sample was analyzed in duplicate for lab duplicate QC purposes: 15301-SE-2 (analyzed 6/18/09 in SDG 1096016). All lab duplicate results were within QAPP tolerance.

The overall frequency of LD and FD is as follows:

QC Frequency for PCB Sediment Samples						
						Frequency of LD
1094733	3	1	4	0	33.3%	0.0%
1096018	3	0	3	0	0.0%	0.0%
1096016	7	1	8	1	14.3%	12.5%
1097888	6	1	7	0	16.7%	0.0%
1097895	2	1	3	0	50.0%	0.0%
1097891	2	0	2	0	0.0%	0.0%
1097894	7	0	7	0	0.0%	0.0%
1098517	3	0	3	0	0.0%	0.0%
1099535	3	0	3	0	0.0%	0.0%
10110354	2	0	2	0	0.0%	0.0%
Overall Frequency					10.5%	2.4%

The overall frequency met the required criteria for FDs and LDs of 5%. Laboratory duplicates were rarely possible for these matrices due to insufficient media. An "F" flag was applied to the parent and FD congeners that were greater than 50% RPD. All lab duplicate RPDs with results above the RL were within the 40% criteria. No flags were required.

### Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- \* Comparing the chain-of-custody procedures to those described in the QAPP;
- \* Evaluating holding times; and
- \* Examining method blanks for contamination of samples during analysis.

The samples in this SDG were collected and analyzed following the QAPP, COC and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis.

All initial calibration criteria were met.

All continuing calibration criteria (BS) were met, with the exception of those listed in the accuracy table.

All LOQ standard criteria were met, with the exception of those listed in "PCB\_QC\_Sed\_Pace\_UH\_2009(P2)" worksheet "PCB Sed Flags".

There was at least one method blank analyzed with each batch associated with the PCBs analyses in each SDG. The method blanks had many PCBs of concern above the RLs. The sample results that were less than five (5) times the amount found in the blank were "B" flagged for having blank contamination.

### **Completeness**

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

No reported results for samples in this SDG have been rejected or invalidated. The completeness for this SDG is 100% compared to the minimum acceptance limit of 90%.

### **COMPARABILITY**

All data was generated using contract-specific standard methods and reported with known data quality, type of analysis, units, etc.

### **DATA USABILITY**

All calculations were spot checked and verified. All data in this SDG are considered usable for the purposes of this project.

## APPENDIX B

### HISTORICAL FISH TISSUE DATA

## INTRODUCTION

In response to a request by USEPA in comments on the draft Preliminary Site Characterization Report, Table B-1 presents historical fish tissue data from three separate fish tissue studies. Those samples collected prior to 2006 are listed. These data are not included in the baseline dataset.

The studies are as follows:

ENSR and EHA, 1995. Houston Ship Channel Toxicity Study. Prepared for the City of Houston, Houston, TX. ENSR Consulting and Engineering, Houston, TX and Espey, Huston and Associates, Austin, TX.

TDSHS, 2010. Texas Fish Tissue Data. Collection of Excel files sent to Jennifer Sampson (Integral) from Michael Tennant (TDSHS) on 1/20/2010 containing tables of fish tissue chemical data collected over several decades from the Galveston Bay area. Texas Department of State Health Services.

University of Houston and Parsons, 2006. Total Maximum Daily Loads for Dioxins in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-02. Quarterly report No. 3. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:  
<http://www.tceq.state.tx.us/assets/public/implementation/water/tmdl/26hscdioxin/26-all-data-compiled-q3-fy06.pdf>.

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
ENSR and EHA (1995)	7	HSC-TS-007B-156A,1	10/1/1993	Blue catfish	Fillet	1.66	
ENSR and EHA (1995)	9	HSC-TS-009-11	10/1/1993	Blue catfish	Fillet	2.31	
ENSR and EHA (1995)	10	HSC-TS-010-13	10/1/1993	Blue catfish	Fillet	0.0181	
ENSR and EHA (1995)	1	HSC-CT-001	10/1/1993	Blue crab	Edible	2.19	
ENSR and EHA (1995)	7	HSC-CT-007	10/1/1993	Blue crab	Edible	5.47	
ENSR and EHA (1995)	9	HSC-CT-009	10/1/1993	Blue crab	Edible	2.47	
ENSR and EHA (1995)	10	HSC-CT-10	10/1/1993	Blue crab	Edible	0.973	
ENSR and EHA (1995)	16	HSC-CT-016	10/1/1993	Blue crab	Edible	0.14	
ENSR and EHA (1995)	17	HSC-CT-017	10/1/1993	Blue crab	Edible	3.46	
TDSHS (2010)	TDSHS_FishLoc82	20040219bcfHSC28	2/19/2004	Blue catfish	Fillet	0.246	
TDSHS (2010)	TDSHS_FishLoc82	20040219bcfHSC29	2/19/2004	Blue catfish	Fillet	0.211	
TDSHS (2010)	TDSHS_FishLoc83	20040210bcfHSC10	2/10/2004	Blue catfish	Fillet	5.43	
TDSHS (2010)	TDSHS_FishLoc83	20040210bcfHSC7	2/10/2004	Blue catfish	Fillet	3.2	
TDSHS (2010)	TDSHS_FishLoc83	20040210bcfHSC9	2/10/2004	Blue catfish	Fillet	7.16	
TDSHS (2010)	TDSHS_FishLoc84	20040210bcfHSC1	2/10/2004	Blue catfish	Fillet	1.5	
TDSHS (2010)	TDSHS_FishLoc84	20040211bcfHSC2	2/11/2004	Blue catfish	Fillet	5.78	
TDSHS (2010)	TDSHS_FishLoc84	20040311bcfHSC4	3/11/2004	Blue catfish	Fillet	0.97	
TDSHS (2010)	TDSHS_FishLoc85	20040311bcfHSC40	3/11/2004	Blue catfish	Fillet	3	
TDSHS (2010)	TDSHS_FishLoc85	20040311bcfHSC41	3/11/2004	Blue catfish	Fillet	8.86	
TDSHS (2010)	TDSHS_FishLoc01	19960411bcbGAL1221	4/11/1996	Blue crab	Edible	0.651	
TDSHS (2010)	TDSHS_FishLoc01	19960411bcbGAL1222	4/11/1996	Blue crab	Edible	2.08	
TDSHS (2010)	TDSHS_FishLoc01	19960411bcbGAL1223	4/11/1996	Blue crab	Edible	1.52	
TDSHS (2010)	TDSHS_FishLoc01	19960411bcbGAL1224	4/11/1996	Blue crab	Edible	0.741	
TDSHS (2010)	TDSHS_FishLoc01	19960411bcbGAL1225	4/11/1996	Blue crab	Edible	1.32	
TDSHS (2010)	TDSHS_FishLoc02	19940609bcbGAL2134	6/9/1994	Blue crab	Edible	1.68	
TDSHS (2010)	TDSHS_FishLoc02	19940609bcbGAL2135	6/9/1994	Blue crab	Edible	1.52	
TDSHS (2010)	TDSHS_FishLoc02	19940609bcbGAL2136	6/9/1994	Blue crab	Edible	2.49	
TDSHS (2010)	TDSHS_FishLoc28	19960411bcbHSC4	4/11/1996	Blue crab	Edible	4.17	
TDSHS (2010)	TDSHS_FishLoc28	19960411bcbHSC5	4/11/1996	Blue crab	Edible	2.62	
TDSHS (2010)	TDSHS_FishLoc28	19960411bcbHSC6	4/11/1996	Blue crab	Edible	5.05	
TDSHS (2010)	TDSHS_FishLoc28	19960411bcbHSC7	4/11/1996	Blue crab	Edible	4.28	

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
TDSHS (2010)	TDSHS_FishLoc28	19960411bcbHSC8	4/11/1996	Blue crab	Edible	4.23	
TDSHS (2010)	TDSHS_FishLoc34	19990615bcbCLC10	6/15/1999	Blue crab	Edible	0.08	
TDSHS (2010)	TDSHS_FishLoc34	19990615bcbCLC8	6/15/1999	Blue crab	Edible	0.0495	
TDSHS (2010)	TDSHS_FishLoc35	19990616bcbCLK8	6/16/1999	Blue crab	Edible	0	U
TDSHS (2010)	TDSHS_FishLoc36	19990615bcbCLK6	6/15/1999	Blue crab	Edible	0.389	
TDSHS (2010)	TDSHS_FishLoc36	19990617bcbCLK20	6/17/1999	Blue crab	Edible	0.522	
TDSHS (2010)	TDSHS_FishLoc36	19990617bcbCLK21	6/17/1999	Blue crab	Edible	0.556	
TDSHS (2010)	TDSHS_FishLoc38	19990818bcbGAL25614	8/18/1999	Blue crab	Edible	0.71	
TDSHS (2010)	TDSHS_FishLoc38	19990818bcbGAL25615	8/18/1999	Blue crab	Edible	0.656	
TDSHS (2010)	TDSHS_FishLoc38	19990825bcbGAL25621	8/25/1999	Blue crab	Edible	0.733	
TDSHS (2010)	TDSHS_FishLoc49	19920416bcbWESS13	4/16/1992	Blue crab	Edible	0	U
TDSHS (2010)	TDSHS_FishLoc81	20040218bcbHSC31	2/18/2004	Blue crab	Edible	0.575	
TDSHS (2010)	TDSHS_FishLoc81	20040310bcbHSC35	3/10/2004	Blue crab	Edible	1.75	
TDSHS (2010)	TDSHS_FishLoc82	20040312bcbHSC32	3/12/2004	Blue crab	Edible	2.58	
TDSHS (2010)	TDSHS_FishLoc82	20040312bcbHSC43	3/12/2004	Blue crab	Edible	2.23	
TDSHS (2010)	TDSHS_FishLoc83	20040407bcbHSC47	4/7/2004	Blue crab	Edible	1.05	
TDSHS (2010)	TDSHS_FishLoc83	20040407bcbHSC48	4/7/2004	Blue crab	Edible	1.39	
TDSHS (2010)	TDSHS_FishLoc84	20040312bcbHSC15	3/12/2004	Blue crab	Edible	2.06	
TDSHS (2010)	TDSHS_FishLoc84	20040312bcbHSC44	3/12/2004	Blue crab	Edible	2.41	
TDSHS (2010)	TDSHS_FishLoc85	20040407bcbHSC45	4/7/2004	Blue crab	Edible	3.11	
TDSHS (2010)	TDSHS_FishLoc85	20040407bcbHSC46	4/7/2004	Blue crab	Edible	3.09	
TDSHS (2010)	TDSHS_FishLoc94	19990818bcbGAL3032	8/18/1999	Blue crab	Edible	1.2	
TDSHS (2010)	TDSHS_FishLoc94	19990824bcbGAL3035	8/24/1999	Blue crab	Edible	1.26	
TDSHS (2010)	TDSHS_FishLoc94	19990826bcbGAL3036	8/26/1999	Blue crab	Edible	0.777	
TDSHS (2010)	TDSHS_FishLoc82	20040219hsbHSC30	2/19/2004	Hybrid striped bass	Fillet	1.52	
TDSHS (2010)	TDSHS_FishLoc85	20040311hsbHSC42	3/11/2004	Hybrid striped bass	Fillet	1.51	
TDSHS (2010)	TDSHS_FishLoc27	19960411rdmTAB3	4/11/1996	Red drum	Fillet	0.466	
TDSHS (2010)	TDSHS_FishLoc34	19990615rdmCLC2	6/15/1999	Red drum	Fillet	0.0283	
TDSHS (2010)	TDSHS_FishLoc37	19990617rdmCLK9	6/17/1999	Red drum	Fillet	0.0222	
TDSHS (2010)	TDSHS_FishLoc49	19920416rdmWESS11	4/16/1992	Red drum	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc81	20040218rdmHSC21	2/18/2004	Red drum	Fillet	0.0982	U

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
TDSHS (2010)	TDSHS_FishLoc81	20040218rdmHSC22	2/18/2004	Red drum	Fillet	0.148	
TDSHS (2010)	TDSHS_FishLoc85	20040311rdmHSC38	3/11/2004	Red drum	Fillet	0.0938	U
TDSHS (2010)	TDSHS_FishLoc85	20040311rdmHSC39	3/11/2004	Red drum	Fillet	2.8	
TDSHS (2010)	TDSHS_FishLoc83	20040210sbfHSC5	2/10/2004	Smallmouth buffalo	Fillet	2.18	
TDSHS (2010)	TDSHS_FishLoc83	20040210sbfHSC8	2/10/2004	Smallmouth buffalo	Fillet	0.903	
TDSHS (2010)	TDSHS_FishLoc84	20040312sbfHSC34	3/12/2004	Smallmouth buffalo	Fillet	3.08	
TDSHS (2010)	TDSHS_FishLoc27	19960411sfrTAB4	4/11/1996	Southern flounder	Fillet	0.971	
TDSHS (2010)	TDSHS_FishLoc28	19960508sfrHSC11	5/8/1996	Southern flounder	Fillet	5.82	
TDSHS (2010)	TDSHS_FishLoc33	19990826sfrGAL3047	8/26/1999	Southern flounder	Fillet	0.0331	
TDSHS (2010)	TDSHS_FishLoc33	19990826sfrGAL3049	8/26/1999	Southern flounder	Fillet	0.996	
TDSHS (2010)	TDSHS_FishLoc33	19990826sfrGAL34-0	8/26/1999	Southern flounder	Fillet	0.268	
TDSHS (2010)	TDSHS_FishLoc34	19990615sfrCLC4	6/15/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc34	19990615sfrCLC6	6/15/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc36	19990617sfrCLK19	6/17/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc37	19990617sfrCLK15	6/17/1999	Southern flounder	Fillet	0.0169	
TDSHS (2010)	TDSHS_FishLoc37	19990617sfrCLK17	6/17/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc37	19990818sfrCLK28	8/18/1999	Southern flounder	Fillet	0.0234	
TDSHS (2010)	TDSHS_FishLoc37	19990818sfrCLK29	8/18/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc37	19990818sfrCLK30	8/18/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc38	19990817sfrGAL2562	6/17/1999	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc38	19990817sfrGAL2563	6/17/1999	Southern flounder	Fillet	0.591	
TDSHS (2010)	TDSHS_FishLoc38	19990817sfrGAL2564	6/17/1999	Southern flounder	Fillet	0.00863	
TDSHS (2010)	TDSHS_FishLoc38	19990817sfrGAL2565	6/17/1999	Southern flounder	Fillet	0.321	
TDSHS (2010)	TDSHS_FishLoc38	19990817sfrGAL2566	6/17/1999	Southern flounder	Fillet	0.252	
TDSHS (2010)	TDSHS_FishLoc49	19920416sfrWES512	4/16/1992	Southern flounder	Fillet	0	U
TDSHS (2010)	TDSHS_FishLoc81	20040218sfrHSC23	2/18/2004	Southern flounder	Fillet	0.189	U
TDSHS (2010)	TDSHS_FishLoc28	19960411sptHSC3	4/11/1996	Spotted seatrout	Fillet	0.711	
TDSHS (2010)	TDSHS_FishLoc33	19990826sptGAL3042	8/26/1999	Spotted seatrout	Fillet	0.0463	
TDSHS (2010)	TDSHS_FishLoc81	20040218sptHSC19	2/18/2004	Spotted seatrout	Fillet	1.73	
TDSHS (2010)	TDSHS_FishLoc81	20040218sptHSC20	2/18/2004	Spotted seatrout	Fillet	0.183	U
TDSHS (2010)	TDSHS_FishLoc82	20040219sptHSC24	2/19/2004	Spotted seatrout	Fillet	0.199	

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
TDSHS (2010)	TDSHS_FishLoc82	20040219sptHSC25	2/19/2004	Spotted seatrout	Fillet	0.2	
TDSHS (2010)	TDSHS_FishLoc85	20040210sptHSC36	2/10/2004	Spotted seatrout	Fillet	0.344	
TDSHS (2010)	TDSHS_FishLoc85	20040311sptHSC37	3/11/2004	Spotted seatrout	Fillet	0.12	U
TDSHS (2010)	TDSHS_FishLoc94	19990824sptGAL3033	8/24/1999	Spotted seatrout	Fillet	0.334	
TDSHS (2010)	TDSHS_FishLoc94	19990824sptGAL3034	8/24/1999	Spotted seatrout	Fillet	0.0288	
University of Houston and Parsons (2006)	11092	030430bcf11092	4/30/2003	Blue catfish	Edible	1.17	J
University of Houston and Parsons (2006)	11092	030430bcf11092-dup	4/30/2003	Blue catfish	Edible	0.856	J
University of Houston and Parsons (2006)	11092	040427bcf11092	4/27/2004	Blue catfish	Edible	0.703	J
University of Houston and Parsons (2006)	11111	040427bcf11111	4/27/2004	Blue catfish	Edible	0.757	J
University of Houston and Parsons (2006)	11193	021120bcf11193	11/20/2002	Blue catfish	Edible	4.9	J
University of Houston and Parsons (2006)	11193	040323bcf11193	3/23/2004	Blue catfish	Edible	5.17	J
University of Houston and Parsons (2006)	11197	040324bcf11197	3/24/2004	Blue catfish	Edible	1.92	J
University of Houston and Parsons (2006)	11197	040324bcf11197-dup	3/24/2004	Blue catfish	Edible	2.58	J
University of Houston and Parsons (2006)	11200	020903bcf11200	9/3/2002	Blue catfish	Edible	1.03	J
University of Houston and Parsons (2006)	11200	021119bcf11200-1	11/19/2002	Blue catfish	Edible	2.93	J
University of Houston and Parsons (2006)	11200	021121bcf11200-2	11/21/2002	Blue catfish	Edible	0.816	J
University of Houston and Parsons (2006)	11252	041003bcf11252	10/3/2004	Blue catfish	Edible	27.3	J
University of Houston and Parsons (2006)	11265	041026bcf11265	10/26/2004	Blue catfish	Edible	9.5	J
University of Houston and Parsons (2006)	11265	041026bcf11265-dup	10/26/2004	Blue catfish	Edible	10.5	J
University of Houston and Parsons (2006)	11272	020726bcf11272	7/26/2002	Blue catfish	Edible	1.48	
University of Houston and Parsons (2006)	11272	020726bcf11272-dup	7/26/2002	Blue catfish	Edible	3	
University of Houston and Parsons (2006)	11272	030430bcf11272	4/30/2003	Blue catfish	Edible	0.983	J
University of Houston and Parsons (2006)	11272	040415bcf11272A	4/15/2004	Blue catfish	Edible	3.61	J
University of Houston and Parsons (2006)	11272	040415bcf11272Adup	4/15/2004	Blue catfish	Edible	1.72	J
University of Houston and Parsons (2006)	11272	040415bcf11272B	4/15/2004	Blue catfish	Edible	1.74	J
University of Houston and Parsons (2006)	11274	020730bcf11274	7/30/2002	Blue catfish	Edible	4.69	
University of Houston and Parsons (2006)	11274	030501bcf11274	5/1/2003	Blue catfish	Edible	3.66	J
University of Houston and Parsons (2006)	11274	040421bcf11274	4/21/2004	Blue catfish	Edible	7.78	J
University of Houston and Parsons (2006)	11287	020825bcf11287	8/25/2002	Blue catfish	Edible	4	J
University of Houston and Parsons (2006)	11287	030505bcf11287	5/5/2003	Blue catfish	Edible	9.03	J
University of Houston and Parsons (2006)	11287	040402bcf11287	4/2/2004	Blue catfish	Edible	2.35	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	11292	020911bcf11292	9/11/2002	Blue catfish	Edible	2.27	J
University of Houston and Parsons (2006)	11292	040403bcf11292	4/3/2004	Blue catfish	Edible	2.73	J
University of Houston and Parsons (2006)	11298	020829bcf11298	8/29/2002	Blue catfish	Edible	0.569	J
University of Houston and Parsons (2006)	11298	030501bcf11298	5/1/2003	Blue catfish	Edible	3.38	J
University of Houston and Parsons (2006)	11298	040422bcf11298	4/22/2004	Blue catfish	Edible	13	J
University of Houston and Parsons (2006)	11300	020906bcf11300	9/6/2002	Blue catfish	Edible	37.5	J
University of Houston and Parsons (2006)	11300	040421bcf11300	4/21/2004	Blue catfish	Edible	19.9	J
University of Houston and Parsons (2006)	11302	020826bcf11302	8/26/2002	Blue catfish	Edible	1.64	J
University of Houston and Parsons (2006)	11302	030501bcf11302	5/1/2003	Blue catfish	Edible	1.23	J
University of Houston and Parsons (2006)	11302	040415bcf11302	4/15/2004	Blue catfish	Edible	2.79	J
University of Houston and Parsons (2006)	11302	040415bcf11302-dup	4/15/2004	Blue catfish	Edible	23.4	J
University of Houston and Parsons (2006)	11305	030503bcf11305	5/3/2003	Blue catfish	Edible	7.09	J
University of Houston and Parsons (2006)	11305	040415bcf11305	4/15/2004	Blue catfish	Edible	3.29	J
University of Houston and Parsons (2006)	11347	020813bcf11347-1	8/13/2002	Blue catfish	Edible	1.72	J
University of Houston and Parsons (2006)	11347	020813bcf11347-2	8/13/2002	Blue catfish	Edible	1.61	J
University of Houston and Parsons (2006)	11347	020813bcf11347-2d	8/13/2002	Blue catfish	Edible	2.3	J
University of Houston and Parsons (2006)	11347	030502bcf11347	5/2/2003	Blue catfish	Edible	3.83	J
University of Houston and Parsons (2006)	11347	040422bcf11347	4/22/2004	Blue catfish	Edible	0.199	J
University of Houston and Parsons (2006)	11382	030502bcf11382	5/2/2003	Blue catfish	Edible	1.56	J
University of Houston and Parsons (2006)	11382	030502bcf11382-dup	5/2/2003	Blue catfish	Edible	3.41	J
University of Houston and Parsons (2006)	13340	041005bcf13340	10/5/2004	Blue catfish	Edible	0.977	J
University of Houston and Parsons (2006)	13342	041029bcf13342	10/29/2004	Blue catfish	Edible	13.9	J
University of Houston and Parsons (2006)	16622	020904bcf16622	9/4/2002	Blue catfish	Edible	4.11	J
University of Houston and Parsons (2006)	16622	030530bcf16622	5/30/2003	Blue catfish	Edible	0.894	J
University of Houston and Parsons (2006)	11092	020802bcb11092	8/2/2002	Blue crab	Edible	0.931	J
University of Houston and Parsons (2006)	11092	030429bcb11092	4/29/2003	Blue crab	Edible	0.643	J
University of Houston and Parsons (2006)	11092	030429bcb11092-dup	4/29/2003	Blue crab	Edible	0.435	J
University of Houston and Parsons (2006)	11092	040430bcb11092	4/30/2004	Blue crab	Edible	0.411	J
University of Houston and Parsons (2006)	11111	020731bcb11111	7/31/2002	Blue crab	Edible	1.14	J
University of Houston and Parsons (2006)	11111	030501bcb11111	5/1/2003	Blue crab	Edible	0.858	J
University of Houston and Parsons (2006)	11111	030501bcb11111-dup	5/1/2003	Blue crab	Edible	1.16	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	11111	040427bcb11111	4/27/2004	Blue crab	Edible	0.832	J
University of Houston and Parsons (2006)	11193	020809bcb11193	8/9/2002	Blue crab	Edible	5.49	J
University of Houston and Parsons (2006)	11193	021021bcb11193	10/21/2002	Blue crab	Edible	1.44	J
University of Houston and Parsons (2006)	11193	030510bcb11193	5/10/2003	Blue crab	Edible	4.51	J
University of Houston and Parsons (2006)	11193	040323bcb11193	3/23/2004	Blue crab	Edible	3.4	J
University of Houston and Parsons (2006)	11193	041027bcb11193	10/27/2004	Blue crab	Edible	14.3	J
University of Houston and Parsons (2006)	11193	041027bcb11193-dup	10/27/2004	Blue crab	Edible	8.65	J
University of Houston and Parsons (2006)	11197	040323bcb11197	3/23/2004	Blue crab	Edible	2.11	J
University of Houston and Parsons (2006)	11197	041028bcb11197	10/28/2004	Blue crab	Edible	8.05	J
University of Houston and Parsons (2006)	11200	020902bcb11200	9/2/2002	Blue crab	Edible	1.03	J
University of Houston and Parsons (2006)	11252	020829bcb11252	8/29/2002	Blue crab	Edible	1.52	J
University of Houston and Parsons (2006)	11252	020829bcb11252-dup	8/29/2002	Blue crab	Edible	1.94	J
University of Houston and Parsons (2006)	11252	021113bcb11252	11/13/2002	Blue crab	Edible	3.02	J
University of Houston and Parsons (2006)	11252	030512bcb11252	5/12/2003	Blue crab	Edible	2.14	J
University of Houston and Parsons (2006)	11252	040309bcb11252	3/9/2004	Blue crab	Edible	2.13	J
University of Houston and Parsons (2006)	11252	041026bcb11252	10/26/2004	Blue crab	Edible	12.1	J
University of Houston and Parsons (2006)	11258	020801bcb11258	8/1/2002	Blue crab	Edible	8.49	J
University of Houston and Parsons (2006)	11258	030430bcb11258	4/30/2003	Blue crab	Edible	2.9	J
University of Houston and Parsons (2006)	11261	020820bcb11261	8/20/2002	Blue crab	Edible	4.68	J
University of Houston and Parsons (2006)	11261	021025bcb11261	10/25/2002	Blue crab	Edible	4.36	J
University of Houston and Parsons (2006)	11261	030510bcb11261	5/10/2003	Blue crab	Edible	2.67	J
University of Houston and Parsons (2006)	11261	040323bcb11261	3/23/2004	Blue crab	Edible	3.27	J
University of Houston and Parsons (2006)	11261	041026bcb11261	10/26/2004	Blue crab	Edible	9.36	J
University of Houston and Parsons (2006)	11264	030506bcb11264	5/6/2003	Blue crab	Edible	2.98	J
University of Houston and Parsons (2006)	11264	040323bcb11264	3/23/2004	Blue crab	Edible	2.95	J
University of Houston and Parsons (2006)	11264	041021bcb11264	10/21/2004	Blue crab	Edible	7.08	J
University of Houston and Parsons (2006)	11265	040330bcb11265	3/30/2004	Blue crab	Edible	2.91	J
University of Houston and Parsons (2006)	11265	041021bcb11265	10/21/2004	Blue crab	Edible	6.5	J
University of Houston and Parsons (2006)	11270	020828bcb11270	8/28/2002	Blue crab	Edible	5.85	J
University of Houston and Parsons (2006)	11270	030506bcb11270	5/6/2003	Blue crab	Edible	5.98	J
University of Houston and Parsons (2006)	11272	020726bcb11272	7/26/2002	Blue crab	Edible	2.04	

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	11272	030429bcb11272	4/29/2003	Blue crab	Edible	0.373	J
University of Houston and Parsons (2006)	11272	040415bcb11272	4/15/2004	Blue crab	Edible	1.69	J
University of Houston and Parsons (2006)	11273	020828bcb11273	8/28/2002	Blue crab	Edible	6.71	J
University of Houston and Parsons (2006)	11273	020828bcb11273-dup	8/28/2002	Blue crab	Edible	10.3	J
University of Houston and Parsons (2006)	11273	030429bcb11273	4/29/2003	Blue crab	Edible	2.31	J
University of Houston and Parsons (2006)	11273	040421bcb11273	4/21/2004	Blue crab	Edible	8.11	J
University of Houston and Parsons (2006)	11273	040421bcb11273-dup	4/21/2004	Blue crab	Edible	9.27	J
University of Houston and Parsons (2006)	11274	020730bcb11274	7/30/2002	Blue crab	Edible	3.65	
University of Houston and Parsons (2006)	11274	030430bcb11274	4/30/2003	Blue crab	Edible	1.78	J
University of Houston and Parsons (2006)	11274	040420bcb11274	4/20/2004	Blue crab	Edible	2.26	J
University of Houston and Parsons (2006)	11280	020828bcb11280	8/28/2002	Blue crab	Edible	5.41	J
University of Houston and Parsons (2006)	11280	020828bcb11280-dup	8/28/2002	Blue crab	Edible	4.06	J
University of Houston and Parsons (2006)	11280	030506bcb11280	5/6/2003	Blue crab	Edible	6.04	J
University of Houston and Parsons (2006)	11280	040401bcb11280	4/1/2004	Blue crab	Edible	6.6	J
University of Houston and Parsons (2006)	11280	041020bcb11280	10/20/2004	Blue crab	Edible	10.6	J
University of Houston and Parsons (2006)	11287	020825bcb11287	8/25/2002	Blue crab	Edible	3.16	J
University of Houston and Parsons (2006)	11287	020825bcb11287-dup	8/25/2002	Blue crab	Edible	10	J
University of Houston and Parsons (2006)	11287	030505bcb11287	5/5/2003	Blue crab	Edible	6.35	J
University of Houston and Parsons (2006)	11287	040401bcb11287	4/1/2004	Blue crab	Edible	5.84	J
University of Houston and Parsons (2006)	11287	041019bcb11287	10/19/2004	Blue crab	Edible	7.51	J
University of Houston and Parsons (2006)	11292	020911bcb11292	9/11/2002	Blue crab	Edible	1	J
University of Houston and Parsons (2006)	11292	030505bcb11292	5/5/2003	Blue crab	Edible	3.01	J
University of Houston and Parsons (2006)	11292	040403bcb11292	4/3/2004	Blue crab	Edible	0.959	J
University of Houston and Parsons (2006)	11292	041020bcb11292	10/20/2004	Blue crab	Edible	2.08	J
University of Houston and Parsons (2006)	11298	020729bcb11298	7/29/2002	Blue crab	Edible	5.8	
University of Houston and Parsons (2006)	11298	030430bcb11298	4/30/2003	Blue crab	Edible	5.76	J
University of Houston and Parsons (2006)	11298	040420bcb11298	4/20/2004	Blue crab	Edible	3	J
University of Houston and Parsons (2006)	11298	040420bcb11298-dup	4/20/2004	Blue crab	Edible	6.08	J
University of Houston and Parsons (2006)	11300	020909bcb11300	9/9/2002	Blue crab	Edible	4.32	J
University of Houston and Parsons (2006)	11300	030530bcb11300	5/30/2003	Blue crab	Edible	3.53	J
University of Houston and Parsons (2006)	11300	040416bcb11300	4/16/2004	Blue crab	Edible	1.97	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	11302	020826bcb11302	8/26/2002	Blue crab	Edible	2	J
University of Houston and Parsons (2006)	11302	030511bcb11302	5/11/2003	Blue crab	Edible	2.39	J
University of Houston and Parsons (2006)	11302	040416bcb11302	4/16/2004	Blue crab	Edible	1.97	J
University of Houston and Parsons (2006)	11305	020814bcb11305	8/14/2002	Blue crab	Edible	1.45	J
University of Houston and Parsons (2006)	11305	030503bcb11305	5/3/2003	Blue crab	Edible	4.42	J
University of Houston and Parsons (2006)	11305	040422bcb11305	4/22/2004	Blue crab	Edible	1.87	J
University of Houston and Parsons (2006)	11347	020812bcb11347	8/12/2002	Blue crab	Edible	4.09	J
University of Houston and Parsons (2006)	11347	030502bcb11347	5/2/2003	Blue crab	Edible	2.63	J
University of Houston and Parsons (2006)	11382	020813bcb11382	8/13/2002	Blue crab	Edible	0.709	J
University of Houston and Parsons (2006)	11382	030502bcb11382	5/2/2003	Blue crab	Edible	2.86	J
University of Houston and Parsons (2006)	13309	020911bcb13309	9/11/2002	Blue crab	Edible	1.83	J
University of Houston and Parsons (2006)	13309	030512bcb13309	5/12/2003	Blue crab	Edible	1.56	J
University of Houston and Parsons (2006)	13336	020828bcb13336	8/28/2002	Blue crab	Edible	1.18	J
University of Houston and Parsons (2006)	13336	021022bcb13336	10/22/2002	Blue crab	Edible	2.83	J
University of Houston and Parsons (2006)	13337	020814bcb13337	8/14/2002	Blue crab	Edible	1.75	J
University of Houston and Parsons (2006)	13337	030523bcb13337	5/23/2003	Blue crab	Edible	2.47	J
University of Houston and Parsons (2006)	13338	020823bcb13338	8/23/2002	Blue crab	Edible	1.38	J
University of Houston and Parsons (2006)	13338	021022bcb13338	10/22/2002	Blue crab	Edible	3.98	J
University of Houston and Parsons (2006)	13338	040317bcb13338	3/17/2004	Blue crab	Edible	1.19	J
University of Houston and Parsons (2006)	13338	041102bcb13338	11/2/2004	Blue crab	Edible	2.57	J
University of Houston and Parsons (2006)	13339	020825bcb13339	8/25/2002	Blue crab	Edible	6.37	J
University of Houston and Parsons (2006)	13339	020825bcb13339-dup	8/25/2002	Blue crab	Edible	5.17	J
University of Houston and Parsons (2006)	13339	030504bcb13339	5/4/2003	Blue crab	Edible	9.22	J
University of Houston and Parsons (2006)	13340	020807bcb13340	8/7/2002	Blue crab	Edible	0.99	J
University of Houston and Parsons (2006)	13340	021022bcb13340	10/22/2002	Blue crab	Edible	2.05	J
University of Houston and Parsons (2006)	13340	030523bcb13340	5/23/2003	Blue crab	Edible	0.977	J
University of Houston and Parsons (2006)	13340	040309bcb13340	3/9/2004	Blue crab	Edible	1.97	J
University of Houston and Parsons (2006)	13340	041103bcb13340	11/3/2004	Blue crab	Edible	1.35	J
University of Houston and Parsons (2006)	13341	020816bcb13341	8/16/2002	Blue crab	Edible	0.927	J
University of Houston and Parsons (2006)	13341	030506bcb13341	5/6/2003	Blue crab	Edible	3.75	J
University of Houston and Parsons (2006)	13342	020824bcb13342	8/24/2002	Blue crab	Edible	5.08	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	13342	021028bcb13342	10/28/2002	Blue crab	Edible	4.99	J
University of Houston and Parsons (2006)	13342	030510bcb13342	5/10/2003	Blue crab	Edible	3.2	J
University of Houston and Parsons (2006)	13342	040309bcb13342	3/9/2004	Blue crab	Edible	5.95	J
University of Houston and Parsons (2006)	13342	041028bcb13342	10/28/2004	Blue crab	Edible	11.1	J
University of Houston and Parsons (2006)	13343	020904bcb13343	9/4/2002	Blue crab	Edible	3.66	J
University of Houston and Parsons (2006)	13343	030510bcb13343	5/10/2003	Blue crab	Edible	5.02	J
University of Houston and Parsons (2006)	13344	020823bcb13344	8/23/2002	Blue crab	Edible	5.81	J
University of Houston and Parsons (2006)	13344	020823bcb13344-dup	8/23/2002	Blue crab	Edible	4.09	J
University of Houston and Parsons (2006)	13344	021027bcb13344	10/27/2002	Blue crab	Edible	5.32	J
University of Houston and Parsons (2006)	13344	021114bcb13344	11/14/2002	Blue crab	Edible	4.15	J
University of Houston and Parsons (2006)	13344	040318bcb13344	3/18/2004	Blue crab	Edible	5.05	J
University of Houston and Parsons (2006)	13344	041021bcb13344	10/21/2004	Blue crab	Edible	4.33	J
University of Houston and Parsons (2006)	13355	020818bcb13355	8/18/2002	Blue crab	Edible	2	J
University of Houston and Parsons (2006)	13355	020818bcb13355-dup	8/18/2002	Blue crab	Edible	2.32	J
University of Houston and Parsons (2006)	13355	030523bcb13355	5/23/2003	Blue crab	Edible	0.893	J
University of Houston and Parsons (2006)	13363	020817bcb13363	8/17/2002	Blue crab	Edible	0.81	J
University of Houston and Parsons (2006)	13363	021116bcb13363	11/16/2002	Blue crab	Edible	0.542	J
University of Houston and Parsons (2006)	13589	020817bcb13589	8/17/2002	Blue crab	Edible	0.948	J
University of Houston and Parsons (2006)	13589	020817bcb13589-dup	8/17/2002	Blue crab	Edible	1.27	J
University of Houston and Parsons (2006)	13589	030516bcb13589	5/16/2003	Blue crab	Edible	0.758	J
University of Houston and Parsons (2006)	14560	020830bcb14560	8/30/2002	Blue crab	Edible	4.09	J
University of Houston and Parsons (2006)	14560	030512bcb14560	5/12/2003	Blue crab	Edible	1.03	J
University of Houston and Parsons (2006)	14560	040309bcb14560	3/9/2004	Blue crab	Edible	1.97	J
University of Houston and Parsons (2006)	14560	041104bcb14560	11/4/2004	Blue crab	Edible	1.57	J
University of Houston and Parsons (2006)	15464	020817bcb15464	8/17/2002	Blue crab	Edible	0.352	J
University of Houston and Parsons (2006)	15464	021113bcb15464	11/13/2002	Blue crab	Edible	0.345	J
University of Houston and Parsons (2006)	15464	030512bcb15464	5/12/2003	Blue crab	Edible	0.676	J
University of Houston and Parsons (2006)	15908	020911bcb15908	9/11/2002	Blue crab	Edible	1.12	J
University of Houston and Parsons (2006)	15908	030522bcb15908	5/22/2003	Blue crab	Edible	0.856	J
University of Houston and Parsons (2006)	15908	030522bcb15908-dup	5/22/2003	Blue crab	Edible	0.556	J
University of Houston and Parsons (2006)	15979	020905bcb15979	9/5/2002	Blue crab	Edible	4.29	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	15979	030523bcb15979	5/23/2003	Blue crab	Edible	2.97	J
University of Houston and Parsons (2006)	15979	040331bcb15979	3/31/2004	Blue crab	Edible	6.25	J
University of Houston and Parsons (2006)	15979	041021bcb15979	10/21/2004	Blue crab	Edible	8.05	J
University of Houston and Parsons (2006)	15979	041021bcb15979-dup	10/21/2004	Blue crab	Edible	14.4	J
University of Houston and Parsons (2006)	16213	020910bcb16213	9/10/2002	Blue crab	Edible	0.748	J
University of Houston and Parsons (2006)	16213	030512bcb16213	5/12/2003	Blue crab	Edible	0.824	J
University of Houston and Parsons (2006)	16496	020824bcb16496	8/24/2002	Blue crab	Edible	4.91	J
University of Houston and Parsons (2006)	16496	030510bcb16496	5/10/2003	Blue crab	Edible	4.07	J
University of Houston and Parsons (2006)	16499	020823bcb16499	8/23/2002	Blue crab	Edible	5.92	J
University of Houston and Parsons (2006)	16499	021024bcb16499	10/24/2002	Blue crab	Edible	3.16	J
University of Houston and Parsons (2006)	16499	040317bcb16499	3/17/2004	Blue crab	Edible	3.83	J
University of Houston and Parsons (2006)	16499	041108bcb16499	11/8/2004	Blue crab	Edible	4.82	J
University of Houston and Parsons (2006)	16618	020820bcb16618	8/20/2002	Blue crab	Edible	15.8	J
University of Houston and Parsons (2006)	16618	030505bcb16618	5/5/2003	Blue crab	Edible	9.71	J
University of Houston and Parsons (2006)	16618	040318bcb16618	3/18/2004	Blue crab	Edible	7.33	J
University of Houston and Parsons (2006)	16618	041102bcb16618	11/2/2004	Blue crab	Edible	6.54	J
University of Houston and Parsons (2006)	16622	020902bcb16622	9/2/2002	Blue crab	Edible	1.37	J
University of Houston and Parsons (2006)	16622	030522bcb16622	5/22/2003	Blue crab	Edible	0.482	J
University of Houston and Parsons (2006)	17970	020818bcb17970	8/18/2002	Blue crab	Edible	4.15	J
University of Houston and Parsons (2006)	17970	021024bcb17970	10/24/2002	Blue crab	Edible	2.13	J
University of Houston and Parsons (2006)	17971	020824bcb17971	8/24/2002	Blue crab	Edible	5.39	J
University of Houston and Parsons (2006)	17971	021028bcb17971	10/28/2002	Blue crab	Edible	5.94	J
University of Houston and Parsons (2006)	17971	021028bcb17971-dup	10/28/2002	Blue crab	Edible	6.11	J
University of Houston and Parsons (2006)	11092	020802hcf11092	8/2/2002	Hardhead catfish	Edible	0.396	J
University of Houston and Parsons (2006)	11111	020801hcf11111	8/1/2002	Hardhead catfish	Edible	3.46	J
University of Houston and Parsons (2006)	11111	030501hcf11111	5/1/2003	Hardhead catfish	Edible	3.28	J
University of Houston and Parsons (2006)	11193	020809hcf11193	8/9/2002	Hardhead catfish	Edible	13.2	J
University of Houston and Parsons (2006)	11193	030514hcf11193	5/14/2003	Hardhead catfish	Edible	5.82	J
University of Houston and Parsons (2006)	11193	041028hcf11193	10/28/2004	Hardhead catfish	Edible	15.1	J
University of Houston and Parsons (2006)	11193	041028hcf11193-dup	10/28/2004	Hardhead catfish	Edible	13.8	J
University of Houston and Parsons (2006)	11197	041028hcf11197	10/28/2004	Hardhead catfish	Edible	15.1	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID <sup>c</sup>	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	11252	020826hcf11252	8/26/2002	Hardhead catfish	Edible	3.17	J
University of Houston and Parsons (2006)	11252	021024hcf11252	10/24/2002	Hardhead catfish	Edible	8.79	J
University of Houston and Parsons (2006)	11252	030516hcf11252	5/16/2003	Hardhead catfish	Edible	2.33	J
University of Houston and Parsons (2006)	11252	040309hcf11252	3/9/2004	Hardhead catfish	Edible	2.23	J
University of Houston and Parsons (2006)	11258	020801hcf11258	8/1/2002	Hardhead catfish	Edible	7.89	J
University of Houston and Parsons (2006)	11258	030428hcf11258	4/28/2003	Hardhead catfish	Edible	5.8	J
University of Houston and Parsons (2006)	11261	020823hcf11261	8/23/2002	Hardhead catfish	Edible	11.7	J
University of Houston and Parsons (2006)	11261	021026hcf11261	10/26/2002	Hardhead catfish	Edible	8.5	J
University of Houston and Parsons (2006)	11261	030510hcf11261	5/10/2003	Hardhead catfish	Edible	10.7	J
University of Houston and Parsons (2006)	11261	040324hcf11261	3/24/2004	Hardhead catfish	Edible	4.64	J
University of Houston and Parsons (2006)	11261	041027hcf11261	10/27/2004	Hardhead catfish	Edible	14.8	J
University of Houston and Parsons (2006)	11264	020820hcf11264	8/20/2002	Hardhead catfish	Edible	8.4	J
University of Houston and Parsons (2006)	11264	030515hcf11264	5/15/2003	Hardhead catfish	Edible	10.8	J
University of Houston and Parsons (2006)	11264	040402hcf11264	4/2/2004	Hardhead catfish	Edible	8.63	J
University of Houston and Parsons (2006)	11264	040402hcf11264-dup	4/2/2004	Hardhead catfish	Edible	6.85	J
University of Houston and Parsons (2006)	11264	041026hcf11264	10/26/2004	Hardhead catfish	Edible	13.8	J
University of Houston and Parsons (2006)	11265	040402hcf11265	4/2/2004	Hardhead catfish	Edible	6.64	J
University of Houston and Parsons (2006)	11270	020828hcf11270	8/28/2002	Hardhead catfish	Edible	5.53	J
University of Houston and Parsons (2006)	11270	030506hcf11270	5/6/2003	Hardhead catfish	Edible	10.6	J
University of Houston and Parsons (2006)	11270	030506hcf11270-dup	5/6/2003	Hardhead catfish	Edible	14.4	J
University of Houston and Parsons (2006)	11273	020830hcf11273	8/30/2002	Hardhead catfish	Edible	8.07	J
University of Houston and Parsons (2006)	11273	030429hcf11273	4/29/2003	Hardhead catfish	Edible	11.2	J
University of Houston and Parsons (2006)	11273	040421hcf11273	4/21/2004	Hardhead catfish	Edible	2.92	J
University of Houston and Parsons (2006)	11280	020828hcf11280	8/28/2002	Hardhead catfish	Edible	5.87	J
University of Houston and Parsons (2006)	11280	030506hcf11280	5/6/2003	Hardhead catfish	Edible	15.1	J
University of Houston and Parsons (2006)	11280	040402hcf11280	4/2/2004	Hardhead catfish	Edible	12.9	J
University of Houston and Parsons (2006)	11280	041021hcf11280	10/21/2004	Hardhead catfish	Edible	19.2	J
University of Houston and Parsons (2006)	11287	041028hcf11287	10/28/2004	Hardhead catfish	Edible	5.26	J
University of Houston and Parsons (2006)	11292	041020hcf11292	10/20/2004	Hardhead catfish	Edible	1.32	J
University of Houston and Parsons (2006)	13309	020830hcf13309	8/30/2002	Hardhead catfish	Edible	3.14	J
University of Houston and Parsons (2006)	13336	020827hcf13336	8/27/2002	Hardhead catfish	Edible	2.71	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	13336	020828hcf13336-dup	8/28/2002	Hardhead catfish	Edible	0.784	J
University of Houston and Parsons (2006)	13336	021022hcf13336	10/22/2002	Hardhead catfish	Edible	2.83	J
University of Houston and Parsons (2006)	13337	020814hcf13337	8/14/2002	Hardhead catfish	Edible	2.78	J
University of Houston and Parsons (2006)	13337	020814hcf13337-dup	8/14/2002	Hardhead catfish	Edible	11.5	J
University of Houston and Parsons (2006)	13337	030528hcf13337	5/28/2003	Hardhead catfish	Edible	6.49	J
University of Houston and Parsons (2006)	13338	020823hcf13338	8/23/2002	Hardhead catfish	Edible	6.69	J
University of Houston and Parsons (2006)	13338	021022hcf13338	10/22/2002	Hardhead catfish	Edible	8.16	J
University of Houston and Parsons (2006)	13338	021022hcf13338-dup	10/22/2002	Hardhead catfish	Edible	3.68	J
University of Houston and Parsons (2006)	13338	040318hcf13338	3/18/2004	Hardhead catfish	Edible	4.61	J
University of Houston and Parsons (2006)	13338	041004hcf13338	10/4/2004	Hardhead catfish	Edible	1.83	J
University of Houston and Parsons (2006)	13339	020823hcf13339	8/23/2002	Hardhead catfish	Edible	6.69	J
University of Houston and Parsons (2006)	13339	020823hcf13339-dup	8/23/2002	Hardhead catfish	Edible	7.5	J
University of Houston and Parsons (2006)	13339	030504hcf13339	5/4/2003	Hardhead catfish	Edible	10	J
University of Houston and Parsons (2006)	13340	020807hcf13340	8/7/2002	Hardhead catfish	Edible	1.98	J
University of Houston and Parsons (2006)	13340	030528hcf13340	5/28/2003	Hardhead catfish	Edible	4.35	J
University of Houston and Parsons (2006)	13340	040309hcf13340	3/9/2004	Hardhead catfish	Edible	1.47	J
University of Houston and Parsons (2006)	13341	020809hcf13341	8/9/2002	Hardhead catfish	Edible	4.9	
University of Houston and Parsons (2006)	13341	030528hcf13341	5/28/2003	Hardhead catfish	Edible	2.33	J
University of Houston and Parsons (2006)	13342	020822hcf13342	8/22/2002	Hardhead catfish	Edible	6.21	J
University of Houston and Parsons (2006)	13342	021028hcf13342	10/28/2002	Hardhead catfish	Edible	2.65	J
University of Houston and Parsons (2006)	13342	030511hcf13342	5/11/2003	Hardhead catfish	Edible	12.9	J
University of Houston and Parsons (2006)	13342	040309hcf13342	3/9/2004	Hardhead catfish	Edible	5.26	J
University of Houston and Parsons (2006)	13343	020820hcf13343	8/20/2002	Hardhead catfish	Edible	6.48	J
University of Houston and Parsons (2006)	13343	030506hcf13343	5/6/2003	Hardhead catfish	Edible	9.67	J
University of Houston and Parsons (2006)	13344	020821hcf13344	8/21/2002	Hardhead catfish	Edible	6.27	J
University of Houston and Parsons (2006)	13344	021027hcf13344	10/27/2002	Hardhead catfish	Edible	10.6	J
University of Houston and Parsons (2006)	13344	040318hcf13344	3/18/2004	Hardhead catfish	Edible	12.3	J
University of Houston and Parsons (2006)	13344	041028hcf13344	10/28/2004	Hardhead catfish	Edible	5.4	J
University of Houston and Parsons (2006)	13355	020818hcf13355	8/18/2002	Hardhead catfish	Edible	2.52	J
University of Houston and Parsons (2006)	13355	030528hcf13355	5/28/2003	Hardhead catfish	Edible	4.84	J
University of Houston and Parsons (2006)	13363	020817hcf13363	8/17/2002	Hardhead catfish	Edible	1.76	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	13589	020817hcf13589	8/17/2002	Hardhead catfish	Edible	1.54	J
University of Houston and Parsons (2006)	13589	020817hcf13589-dup	8/17/2002	Hardhead catfish	Edible	1.23	J
University of Houston and Parsons (2006)	13589	030516hcf13589	5/16/2003	Hardhead catfish	Edible	0.788	J
University of Houston and Parsons (2006)	14560	020830hcf14560	8/30/2002	Hardhead catfish	Edible	1.5	J
University of Houston and Parsons (2006)	14560	030512hcf14560	5/12/2003	Hardhead catfish	Edible	16	J
University of Houston and Parsons (2006)	14560	040309hcf14560	3/9/2004	Hardhead catfish	Edible	4.89	J
University of Houston and Parsons (2006)	14560	041003hcf14560	10/3/2004	Hardhead catfish	Edible	1.21	J
University of Houston and Parsons (2006)	15464	020818hcf15464	8/18/2002	Hardhead catfish	Edible	0.697	J
University of Houston and Parsons (2006)	15908	020911hcf15908	9/11/2002	Hardhead catfish	Edible	2.88	J
University of Houston and Parsons (2006)	15908	020911hcf15908-dup	9/11/2002	Hardhead catfish	Edible	6.79	J
University of Houston and Parsons (2006)	15908	030528hcf15908	5/28/2003	Hardhead catfish	Edible	3.17	J
University of Houston and Parsons (2006)	15979	020905hcf15979	9/5/2002	Hardhead catfish	Edible	11.7	J
University of Houston and Parsons (2006)	15979	030529hcf15979	5/29/2003	Hardhead catfish	Edible	11.6	J
University of Houston and Parsons (2006)	15979	040331hcf15979	3/31/2004	Hardhead catfish	Edible	13.9	J
University of Houston and Parsons (2006)	15979	041026hcf15979	10/26/2004	Hardhead catfish	Edible	7.63	J
University of Houston and Parsons (2006)	16213	020911hcf16213	9/11/2002	Hardhead catfish	Edible	3.02	J
University of Houston and Parsons (2006)	16213	030512hcf16213	5/12/2003	Hardhead catfish	Edible	2.45	J
University of Houston and Parsons (2006)	16496	020821hcf16496	8/21/2002	Hardhead catfish	Edible	6.6	J
University of Houston and Parsons (2006)	16496	030511hcf16496	5/11/2003	Hardhead catfish	Edible	11	J
University of Houston and Parsons (2006)	16496	030511hcf16496-dup	5/11/2003	Hardhead catfish	Edible	11	J
University of Houston and Parsons (2006)	16499	020823hcf16499	8/23/2002	Hardhead catfish	Edible	4.84	J
University of Houston and Parsons (2006)	16499	020823hcf16499-dup	8/23/2002	Hardhead catfish	Edible	8.76	J
University of Houston and Parsons (2006)	16499	021024hcf16499	10/24/2002	Hardhead catfish	Edible	7.28	J
University of Houston and Parsons (2006)	16499	040318hcf16499	3/18/2004	Hardhead catfish	Edible	4.38	J
University of Houston and Parsons (2006)	16499	041029hcf16499	10/29/2004	Hardhead catfish	Edible	4.96	J
University of Houston and Parsons (2006)	16618	020819hcf16618	8/19/2002	Hardhead catfish	Edible	6.83	J
University of Houston and Parsons (2006)	16618	030505hcf16618	5/5/2003	Hardhead catfish	Edible	9.85	J
University of Houston and Parsons (2006)	16618	040318hcf16618	3/18/2004	Hardhead catfish	Edible	3.45	J
University of Houston and Parsons (2006)	16618	041003hcf16618	10/3/2004	Hardhead catfish	Edible	3.48	J
University of Houston and Parsons (2006)	17970	020818hcf17970	8/18/2002	Hardhead catfish	Edible	2.01	J
University of Houston and Parsons (2006)	17970	021024hcf17970	10/24/2002	Hardhead catfish	Edible	3.01	J

**Table B-1**  
**Historical Fish Tissue Data for Dioxins and Furnas as TEQ<sub>DF</sub><sup>a</sup>**

Study	Location ID	Sample ID	Sample Date	Species (Common Name)	Tissue Type	Concentration (ng/kg ww) <sup>b,c</sup>	Qualifier
University of Houston and Parsons (2006)	17970	021024hcf17970-dup	10/24/2002	Hardhead catfish	Edible	5.49	J
University of Houston and Parsons (2006)	17971	020824hcf17971	8/24/2002	Hardhead catfish	Edible	3.77	J
University of Houston and Parsons (2006)	17971	021028hcf17971	10/28/2002	Hardhead catfish	Edible	8.43	J

**Notes**

J = estimated

U = undetected

ww = wet weight

<sup>a</sup> Calculated with non-detects set at one-half the detection limit.

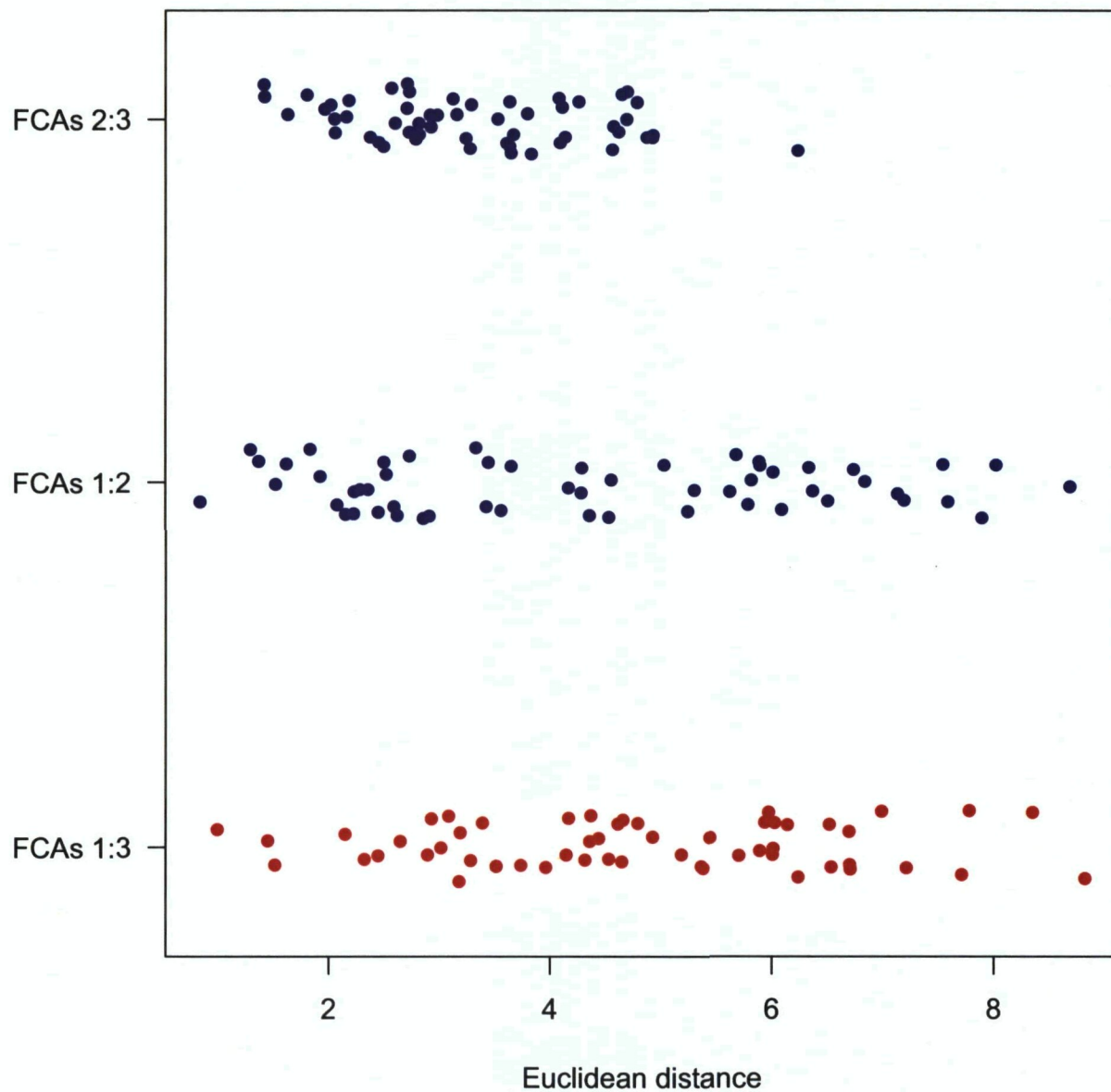
<sup>b</sup> The wet weight designation is assumed in some instances because this is the convention in reporting tissue data.

<sup>c</sup> Values reported here have been adjusted to a maximum of three significant figures for presentation purposes. The actual number of significant figures varies and more precise numbers are available in the database.

## APPENDIX C

### RESULTS FOR STATISTICAL COMPARISONS OF FCAS

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**Note:**

COPC concentrations were centered and scaled prior to the distance calculation. Concentrations in FCAs 1 and 3 were statistically significantly different for mercury, so this comparison is shown in red. Concentrations in FCA 2 were not statistically different from either FCA 1 or FCA 3.

**Table C-1**  
**Pair-wise Statistical Comparisons of FCAs: COPC<sub>Hs</sub><sup>a</sup>**

COPC <sub>H</sub>	FCAs for Comparison			
		FCA1	FCA2	FCA3
<b>Hardhead Catfish</b>				
Arsenic	FCA1	1	0.7	0.03
	FCA2	0.7	1	0.1
	FCA3	0.03	0.1	1
BEHP	FCA1	NA	NA	NA
	FCA2	NA	NA	NA
	FCA3	NA	NA	NA
Cadmium	FCA1	1	0.9	0.4
	FCA2	0.9	1	0.2
	FCA3	0.4	0.2	1
Chromium	FCA1	1	0.6	0.8
	FCA2	0.6	1	0.8
	FCA3	0.8	0.8	1
Copper	FCA1	1	0.02	0.02
	FCA2	0.02	1	0.6
	FCA3	0.02	0.6	1
Mercury	FCA1	1	0.03	0.002
	FCA2	0.03	1	0.1
	FCA3	0.002	0.1	1
Nickel	FCA1	1	0.06	0.7
	FCA2	0.06	1	0.2
	FCA3	0.7	0.2	1
PCB-43Cong	FCA1	1	1.0	0.4
	FCA2	1.0	1	0.3
	FCA3	0.4	0.3	1
TEQ <sub>DF</sub>	FCA1	1	0.2	0.6
	FCA2	0.2	1	0.3
	FCA3	0.6	0.3	1
Zinc	FCA1	1	0.2	0.09
	FCA2	0.2	1	0.3
	FCA3	0.09	0.3	1
<b>Edible Blue Crab</b>				
Arsenic	FCA1	1	0.9	0.05
	FCA2	0.9	1	0.03
	FCA3	0.05	0.03	1
BEHP	FCA1	NA	NA	NA
	FCA2	NA	NA	NA
	FCA3	NA	NA	NA
Cadmium	FCA1	1	0.2	0.006
	FCA2	0.2	1	0.4
	FCA3	0.006	0.4	1

**Table C-1**  
**Pair-wise Statistical Comparisons of FCAs: COPC<sub>H</sub>s<sup>a</sup>**

COPC <sub>H</sub>	FCAs for Comparison			
		FCA1	FCA2	FCA3
Chromium	FCA1	1	0.1	0.01
	FCA2	0.1	1	0.4
	FCA3	0.01	0.4	1
Copper	FCA1	1	0.3	0.6
	FCA2	0.3	1	0.7
	FCA3	0.6	0.7	1
Mercury	FCA1	1	0.0006	0.005
	FCA2	0.0006	1	0.04
	FCA3	0.005	0.04	1
Nickel	FCA1	NA	NA	NA
	FCA2	NA	NA	NA
	FCA3	NA	NA	NA
PCB-43Cong	FCA1	1	0.0008	0.002
	FCA2	0.0008	1	0.04
	FCA3	0.002	0.04	1
TEQ <sub>DF</sub>	FCA1	1	0.009	0.0004
	FCA2	0.009	1	0.1
	FCA3	0.0004	0.1	1
Zinc	FCA1	1	0.2	1
	FCA2	0.2	1	0.5
	FCA3	1	0.5	1
<b>Edible Clam</b>				
Arsenic	FCA1	1	0.04	0.06
	FCA2	0.04	1	0.6
	FCA3	0.06	0.6	1
BEHP	FCA1	NA	NA	NA
	FCA2	NA	NA	NA
	FCA3	NA	NA	NA
Cadmium	FCA1	1	0.6	0.7
	FCA2	0.6	1	0.2
	FCA3	0.7	0.2	1
Chromium	FCA1	1	0.9	1
	FCA2	0.9	1	0.7
	FCA3	1	0.7	1
Copper	FCA1	1	0.009	0.01
	FCA2	0.009	1	0.3
	FCA3	0.01	0.3	1
Mercury	FCA1	1	0.7	0.06
	FCA2	0.7	1	0.3
	FCA3	0.06	0.3	1

**Table C-1**  
**Pair-wise Statistical Comparisons of FCAs: COPC<sub>H</sub>s<sup>a</sup>**

COPC <sub>H</sub>	FCAs for Comparison			
		FCA1	FCA2	FCA3
Nickel	FCA1	1	0.004	0.01
	FCA2	0.004	1	0.6
	FCA3	0.01	0.6	1
PCB-43Cong	FCA1	1	0.04	0.01
	FCA2	0.04	1	0.7
	FCA3	0.01	0.7	1
TEQ <sub>DF</sub>	FCA1	1	0.03	0.06
	FCA2	0.03	1	0.007
	FCA3	0.06	0.007	1
Zinc	FCA1	1	0.9	0.01
	FCA2	0.9	1	0.003
	FCA3	0.01	0.003	1

**Notes**

BEHP = bis(2-ethylhexyl)phthalate

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

FCA = fish collection area

NA = not applicable, all samples were non-detect

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Statistical significance was evaluated at an overall *p* of 0.05. For hardhead catfish and clam where there are nine detected COPC<sub>H</sub>s, individual COPC<sub>H</sub>s were evaluated at a *p*-value of 0.0056 based on the Bonferroni correction for multiple comparisons. For crab, where there are eight detected COPC<sub>H</sub>s, individual COPC<sub>H</sub>s were evaluated at a *p*-value of 0.006 based on the correction factor. Significant *p*-values are highlighted.

**APPENDIX D**  
**DETECTION FREQUENCIES FOR**  
**SEDIMENT, TISSUE, AND SOIL**  
**EXPOSURE UNITS**

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**Table D-1**  
**Detection Frequency in Sediment by Exposure Unit, Area North of I-10 and Aquatic Environment <sup>a</sup>**

COPC <sub>H</sub>	Beach Area A	Beach Area B/C	Beach Area D	Beach Area E
<b>Dioxins/Furans</b>				
TEQ <sub>DF</sub>	5/5	10/10	7/7	17/17
<b>Metals</b>				
Arsenic	5/5	10/10	7/7	13/13
Cadmium	0/5	4/10	7/7	11/13
Chromium <sup>b</sup>	4/5	10/10	7/7	13/13
Copper	2/5	10/10	7/7	13/13
Mercury <sup>c</sup>	5/5	8/10	6/7	13/13
Nickel	1/5	10/10	7/7	13/13
Zinc	5/5	10/10	7/7	13/13
<b>Polychlorinated Biphenyls</b>				
TEQ <sub>p</sub>	--	--	--	4/4
Sum of Aroclors	--	--	--	0/4
<b>Semivolatile Organic Compounds</b>				
Bis(2-ethylhexyl)phthalate	0/5	5/10	5/7	13/13

**Notes**

-- = Not available, COPC<sub>H</sub> not analyzed  
COPC<sub>H</sub> = chemical of potential concern for human health  
TCRA = time critical removal action  
TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans  
TEQ<sub>p</sub> = toxicity equivalent for dioxin-like PCBs

a - All beach areas were accessible under pre-TCRA conditions. Only Beach Area A is accessible to humans under post-TCRA conditions.

b - Available data are for total chromium.

c - Available data are for total mercury.

**Table D-2**  
**Detection Frequency in Fish and Shellfish by Exposure Unit, Area North of I-10 and Aquatic**  
**Environments**

<b>Tissue Type and COPC<sub>H</sub></b>		
<b>Hardhead Catfish - Fillet</b>	<b>FCA1</b>	<b>FCA2/3</b>
<b>Dioxins/Furans</b>		
TEQ <sub>DF</sub>	10/10	20/20
<b>Metals</b>		
Arsenic	10/10	20/20
Cadmium	2/10	2/20
Chromium <sup>a</sup>	5/10	8/20
Copper	10/10	20/20
Mercury <sup>b</sup>	10/10	20/20
Nickel	10/10	19/20
Zinc	10/10	20/20
<b>Polychlorinated Biphenyls</b>		
Total Congeners <sup>c</sup> , TEQp	13/13	20/20
<b>Semivolatile Organic Compounds</b>		
Bis(2-ethylhexyl)phthalate	0/10	0/20
<b>Crab - Edible</b>	<b>FCA 1</b>	<b>FCA2/3</b>
<b>Dioxins/Furans</b>		
TEQ <sub>DF</sub>	10/10	12/20
<b>Metals</b>		
Arsenic	10/10	20/20
Cadmium	10/10	20/20
Chromium <sup>a</sup>	9/10	8/20
Copper	10/10	20/20
Mercury <sup>b</sup>	10/10	20/20
Nickel	0/10	0/20
Zinc	10/10	20/20
<b>Polychlorinated Biphenyls</b>		
Total Congeners <sup>c</sup> , TEQp	10/10	20/20
<b>Semivolatile Organic Compounds</b>		
Bis(2-ethylhexyl)phthalate	0/10	0/20
<b>Clam - Edible</b>	<b>FCA1/3</b>	<b>FCA 2</b>
<b>Dioxins/Furans</b>		
TEQ <sub>DF</sub>	10/10	15/15
<b>Metals</b>		
Arsenic	10/10	15/15
Cadmium	10/10	15/15

**Table D-2**  
**Detection Frequency in Fish and Shellfish by Exposure Unit, Area North of I-10 and Aquatic Environments**

<b>Tissue Type and COPC<sub>H</sub></b>		
Chromium <sup>a</sup>	10/10	15/15
Copper	10/10	15/15
Mercury <sup>b</sup>	10/10	13/15
Nickel	10/10	15/15
Zinc	10/10	15/15
<b>Polychlorinated Biphenyls</b>		
Total Congeners <sup>c</sup> , TEQp	10/10	15/15
<b>Semivolatile Organic Compounds</b>		
Bis(2-ethylhexyl)phthalate	0/10	0/15

**Notes**

COPC<sub>H</sub> = chemical of potential concern for human health

FCA = fish collection area

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>p</sub> = toxicity equivalent for dioxin-like PCBs

a - Available data are for total chromium.

b - Available data are for total mercury.

c - Total congeners will be calculated as the sum of 43 PCB congeners, as described in Table 5.

**Table D-3**  
**Detection Frequency in Soils, Area North of I-10 and Aquatic Environment**

COPC <sub>H</sub>	Soils North of I-10	Soils North of I-10 POST-TCRA <sup>a</sup>
<b>Dioxins /Furans</b>		
TEQ <sub>DF</sub>	46/46	6/6
<b>Metals</b>		
Arsenic	36/36	6/6
Cadmium	33/36	6/6
Chromium <sup>b</sup>	36/36	6/6
Copper	36/36	6/6
Mercury <sup>c</sup>	34/36	5/6
Nickel	35/36	6/6
Zinc	36/36	6/6
<b>Polychlorinated Biphenyls</b>		
TEQ <sub>p</sub>	11/12	2/2
Sum of Aroclors	4/15	0/2
<b>Semivolatile Organic Compounds</b>		
Bis(2-ethylhexyl)phthalate	24/36	6/6

**Notes**

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>p</sub> = toxicity equivalent for dioxin-like PCBs

a - The areal extent of accessible soils is limited due to fencing constructed as part of the TCRA.

Only sample locations SJTS028 to -031, TxDOT001, and TxDOT007 are accessible for the post-TCRA scenario.

b - Available data are for total chromium.

c - Available data are for total mercury.

**Table D-4**  
**Detection Frequency in Soils, South Impoundment Area <sup>a,b</sup>**

Analyte <sup>c</sup>	Surface Soils <sup>d</sup>	Shallow Subsurface Soils <sup>e</sup>
<b>Dioxins/Furans</b>		
TEQ <sub>DF</sub>	13/13	10/10
<b>Metals</b>		
Arsenic	10/10	10/10
Thallium	8/10	5/10

**Notes**

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

EPC = exposure point concentration

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - The TCRA did not impact the accessibility of soils in the south impoundment area. Sample size and frequency of detection shown are applicable to pre- and post-TCRA scenarios.

b - Data are from Phase I only. Phase II sampling will be conducted in the first quarter of 2012.

c - Selection of COPC<sub>H</sub>s for the south impoundment area is in progress. Phase I soil investigation results for TEQ<sub>DF</sub>, arsenic, and thallium exceeded risk-based human health screening levels protective of workers and may become COPC<sub>H</sub>s. Therefore, the results for these analytes are shown here.

d - Surface soils include 0- to 6-inch and 0- to 2-foot samples. Surface soils will be used to calculate EPCs for trespassers.

e - Shallow subsurface soils include 6- to 12-inch samples. A depth weighted average for co-located samples will be used in the derivation of EPCs for workers.

APPENDIX E  
CONTRIBUTION OF INDIVIDUAL DIOXIN  
CONGENERS TO  $TEQ_{DF}$  IN TISSUE

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**Table E-1**  
**Percent Contribution of Each Dioxin and Furan to Total TEQ<sub>DF</sub> among Site Tissue Samples**

Analyte	Catfish Fillet			Edible Crab			Edible Clam		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
2,3,7,8-TCDD	82.9	96.6	93.2	16.1	77.7	45.3	33.1	80.4	60.5
1,2,3,7,8-PeCDD	0.528	7.12	2.59	1.6	43.2	13	0.0925	14.5	2.81
1,2,3,4,7,8-HxCDD	0.0299	0.5	0.125	0.146	2.13	0.965	0.0118	1.13	0.261
1,2,3,6,7,8-HxCDD	0.128	3.6	0.788	0.186	2.7	1.3	0.0138	1.96	0.401
1,2,3,7,8,9-HxCDD	0.0355	1.29	0.215	0.156	2.34	1.1	0.0124	1.26	0.324
1,2,3,4,6,7,8-HpCDD	0.039	0.725	0.109	0.0424	0.664	0.204	0.00919	7.02	0.509
OCDD	0.00325	0.0208	0.006	0.00526	0.22	0.035	0.00421	1.47	0.13
2,3,7,8-TCDF	0.204	3.29	1.56	1.57	31.4	17.5	15.3	46.6	32.4
1,2,3,7,8-PeCDF	0.00917	0.0873	0.0293	0.054	0.643	0.336	0.00869	0.368	0.0983
2,3,4,7,8-PeCDF	0.224	2.57	1.14	0.511	6.21	3.25	0.0855	3.51	0.937
1,2,3,4,7,8-HxCDF	0.0241	0.179	0.0683	0.121	1.82	0.804	0.0266	3.66	0.423
1,2,3,6,7,8-HxCDF	0.0237	0.172	0.0589	0.115	1.75	0.808	0.00768	1.86	0.318
1,2,3,7,8,9-HxCDF	0.0274	0.207	0.0753	0.139	2.42	0.991	0.0111	1.86	0.366
2,3,4,6,7,8-HxCDF	0.0254	0.192	0.0665	0.124	1.8	0.828	0.00831	1.64	0.344
1,2,3,4,6,7,8-HpCDF	0.00226	0.0188	0.00715	0.0148	0.304	0.1	0.00119	2.74	0.135
1,2,3,4,7,8,9-HpCDF	0.00308	0.0307	0.0102	0.0192	0.407	0.138	0.00167	0.296	0.0467
OCDF	0.000101	0.00418	0.000588	0.00136	0.0362	0.00799	0.0000318	0.366	0.0164

**Notes**

All values are percentages.

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TCDD/TCDF = tetrachlorinated dibenzodioxins/furans

PeCDD/PeCDF = pentachlorinated dibenzodioxins/furans

HxCDD/HxCDF = hexachlorinated dibenzodioxins/furans

HpCDD/HpCDF = heptachlorinated dibenzodioxins/furans

OCDD/OCDF = octachlorinated dibenzodioxins/furans

**APPENDIX F**  
**EPA COMMENTS RELATING TO THE**  
**DRAFT EXPOSURE ASSESSMENT**  
**MEMORANDUM, AND RESPONSES**

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EPA Comments Relating to the Draft Exposure Assessment Memorandum, and Responses

Comment No.	Section	Page	Comment	Response to Comment - Proposed Revision
1	2	2-1	This section discusses exposure scenarios and whether or not they are considered potentially complete. The exposure pathways from surface water to both fishers, recreational visitors, and trespassers, have been deemed complete/minor and therefore only qualitatively assessed. The report shall clarify and expand the qualitative assessment of these pathways.	<p>The qualitative discussion of pathways defined as potentially complete but minor to be included in the baseline human health risk assessment (BHHRA) will use information about the physical-chemical properties of the COPCs to inform the likely extent of their presence in certain exposure media. In addition, the likelihood, frequency, and intensity with which these pathways are anticipated to occur at the Site will be discussed.</p> <p>Text will be added to Section 2 that describes the manner in which minor pathways will be evaluated.</p>
2	2; Figure 1	2-1	Organisms except invertebrates have been deemed complete/minor for porewater. However, if birds disturb sediment, then they could be exposed to quite a bit of porewater. To illustrate this point, consider wading birds that forage by grabbing food items from the sediment. Quantitative assessment of porewater shall be included for appropriate bird models.	The requested addition is not relevant to the exposure assessment for human receptors. No changes will be made to the Exposure Assessment Memorandum (EA Memo) to address this comment.
3	3.1	3-2	The text states that only TEQ <sub>DF</sub> , arsenic, and thallium exceeded screening values in all surface and subsurface samples from Phase 1 sampling for the south impoundment. However, several Phase 1 PCB analyses exceeded the PCB industrial screening level of 740 µg/kg. For example, SB001 had 1310 µg/kg in one sample, and SB005 had 897 µg/kg in another. The text shall be revised to include PCB as exceeding the screening values.	<p>The analysis summarized by the statement cited in the comment was performed consistent with Section 3.3 of the EA Memo, second paragraph: "Following USEPA (1989) guidance, for any COPC<sub>H</sub> detected at least once in a given medium, nondetected results that exceed the highest detected concentration will be excluded...."</p> <p>Thus, only detected concentrations of TEQ<sub>DF</sub>, arsenic, and thallium from Phase 1 sampling for the south impoundment exceeded screening values. Total PCBs as the sum of Aroclors exceeded screening concentrations only when all Aroclors in a sample were below detection limits. According to the Data Management Plan (Appendix A to the RI/FS Work Plan), aggregate values such as total PCBs are U-qualified, or "nondetect," when all components of the aggregate are U-qualified. Only the U-qualified (non-detect) results for total PCBs were higher than the industrial screening level of 740 µg/kg. Because of the data treatment rules described in Section 3.3, these samples were not tabulated among those exceeding screening values.</p> <p>This clarification will be provided as a footnote in the final EA Memo.</p>
4	3.1	3-2	This section identifies metals and inorganics as chemicals of potential concern for human health (also Table 1 of this document). However, this list is not completely reflective of the list identified in the Preliminary Site Characterization Report (July 2011 – Table 1-2). This section shall clarify the difference between the tables.	<p>The difference between Table 1 of the EA Memo and the list of COPCs for the BHHRA provided in the Preliminary Site Characterization Report (PSCR) (i.e., the inclusion of thallium in Table 1 of the EA Memo) is clearly explained in Section 3.1, as follows:</p> <p>"Analyses of the sediment data according to methods described in the Sediment SAP are documented in the COPC Technical Memorandum (Integral 2011a) and resulted in determination of the final list of COPC<sub>H</sub>s for the area north of I-10 and the aquatic environment (Table 1). Selection of COPC<sub>H</sub>s for the south impoundment area is in progress. According to a comparison of the Phase 1 soil investigation results to risk-based human health screening levels protective of workers, only TEQ<sub>DF</sub>, arsenic, and thallium exceeded screening concentrations in all surface and subsurface samples for which they were analyzed (Integral 2011c, Attachment A). <b>Although thallium is not a COPC<sub>H</sub> according to analyses of information for the north impoundment, it may be determined to be a COPC<sub>H</sub> for the south impoundment, and is therefore addressed in this memorandum and listed in Table 1.</b>" (emphasis added)</p> <p>In addition, chemicals to be addressed only for ecological receptors were listed in the PSCR, but are not shown in the EA Memo, because the EA Memo addresses only human exposure analysis.</p> <p>A footnote will be added to the table for further clarification.</p>

EPA Comments Relating to the Draft Exposure Assessment Memorandum, and Responses

Comment No.	Section	Page	Comment	Response to Comment - Proposed Revision
5	3.2.2.3	3-8	This section discusses calculating a depth-weighted average soil concentration to represent the 0 – 12 inch interval. An explanation of how a depth-weighted average will be calculated shall be included.	An explanation of the approach for calculating a depth-weighted average will be added to Section 3.5, Exposure Point Concentrations.
7 <sup>a</sup>	3.4	3-11	This section discusses the exposure units for the risk assessment. The exposure units shall include sediments and aquatic environment outside of the 1966 perimeter (out to the “blue” preliminary site boundary). Although data indicate mostly very low levels, the risk is still undetermined for this area.	The exposure units for sediments discussed in Section 3.4.1 and shown in Figure 7 do include sediments outside of the 1966 perimeter of the northern impoundments. The samples included in the sediment exposure units reflect the sediments with which human receptors can reasonably be expected to regularly come into contact. Sediments in areas of the site submerged under deeper water are not likely to be regularly contacted by people. This concept is explained in Section 3.2.2.1 of the EA Memo. The basis for the definition of sediment exposure units was established by the DQOs for the sediment study, in Section 1.10.2.2 of the Sediment Sampling and Analysis Plan (SAP). The exposure units are consistent with the approved Sediment SAP and the analyses presented in the approved COPC Technical Memorandum. No revisions will be made to the sediment exposure units.
8	3.4 Table 6		The beach areas B/C and D shall be included as Post-TCRA sediment exposure units using the Trespasser scenario. A person climbing or otherwise going [through] the TCRA fence defines the perfect trespassing scenario. Also, the Post-TCRA soil exposure units shall be the same as for Pre-TCRA (with exception of the actual TCRA cap) for the Trespasser scenario.	The TCRA includes certain institutional controls limiting access to the area of the impoundment north of I-10. These institutional controls were considered when determining exposure units for the human receptors north of I-10.  As stated in the EA Memo, the purpose of evaluating the post-TCRA scenario is to inform an analysis of costs and benefits associated with remedial alternatives. By necessity, the evaluation of the post-TCRA scenario recognizes that the fence is regularly maintained, and effectively limits access to the site.
9	3.4 Table 6		The Big Star property soil samples shall be an exposure unit separate from the soil samples actually in/on the waste pits. These two areas are clearly very different, both from an exposure and risk standpoint. A single exposure point concentration for these combined will significantly underestimate risk of the pits.	The risks associated with exposures to the material within the 1966 impoundment perimeter will be completely addressed. Note that the exposure units for sediments include “Beach Area E,” which consists entirely of the area within the 1966 impoundment perimeter. Risks associated with exposure to the materials in this area will be adequately characterized.
10	3.4 Table 6		An appropriate exposure unit for water shall be included.	Please see response to Comment 1. Because direct contact with water is considered a minor pathway, it will not be addressed quantitatively.
11	3.4.2	3-12	The short paragraph on Post-TCRA tissue modeling is unclear. It states that tissue concentrations will be calculated using the statistical relationship between sediment and tissue data within the tissue exposure unit. Clarify whether sediment or tissue data (or both) from within the tissue exposure unit be used. Clarification is also needed as to how these calculations will be performed, and why such is appropriate.	The Post-TCRA modeling will rely on the relationships established in the Technical Memorandum on Bioaccumulation Modeling (Integral 2010c) and the PSCR (Integral and Anchor QEA 2012). Post-TCRA tissue concentrations will be calculated using sediment data for dioxin and furan congeners when a statistical relationship has been established. Clarification and additional detail on the approach to be used will be provided in the final EA Memo.
12	3.4.2.1.1	3-13	This section shall include an explanation and justification as to why analyses were conducted to assess data similarities and whether or not to pool data sets.	Data are pooled where possible to generate larger datasets, leading to more robust statistical analyses, as explained on p. 3-10 of the EA Memo. The analyses performed as described in Section 3.4 were presented in the DQOs for the tissue study, in Section 1.8.3 of the Tissue SAP (Integral 2010a). The explanation and rationale for the pooling of exposure units are included in Section 3.4 of the EA Memo.

EPA Comments Relating to the Draft Exposure Assessment Memorandum, and Responses

Comment No.	Section	Page	Comment	Response to Comment - Proposed Revision
13	3.4.2.1.2	3-14	The calculation of site-specific Biota-Sediment Accumulation Factors (BSAFs) is important in order to be able to determine the acceptable sediment concentration to be protective of the human consumption of edible fish and shellfish. The calculation of BSAFs shall be included.	<p>As noted in the response to comments on the draft PSCR, this topic will be addressed in the RI Report.</p> <p>The Technical Memorandum on Bioaccumulation Modeling (Integral 2010c) describes the circumstances under which BSAFs may be used to derive concentrations in sediment that are associated with specific tissue concentrations. The Tissue SAP (Integral 2010a) includes calculation of BSAFs among DQOs, in response to a request by USEPA comments on that document. Because the potential use of BSAFs is to identify acceptable sediment concentrations (as noted by the comment), the presentation of BSAFs should be in the RI Report, which will address preliminary sediment remediation goals in depth. Presentation of BSAFs requires this broader context.</p>
14	3.5.1	3-20	These are distributions other than normal and log-normal. The report shall explain why no other distribution will be considered and why this is appropriate.	<p>The text does recognize and explain how data with distributions other than normal and log-normal will be treated in a series of bullets at the end of Section 5.1. Clarifying text will be added to Section 3.5.1, second paragraph, third bullet to explain the treatment of such distributions, as shown below, in bold.</p> <p style="padding-left: 40px;">"For <b>other or</b> unknown data distributions (i.e., those distributions that are not normal and cannot be transformed to a log-normal distribution), the arithmetic mean will be chosen as the CT EPC. The lesser of the 95UCL, based on an unknown distribution, and the maximum value for the dataset will be selected for the RM EPC."</p>
15	4	4-1, Footnote 9	The following changes shall be made: change "evaluating" to "evaluated", and change "level exposure" to "level of exposure".	These typographical errors will be corrected.
16	4.1	4-6	This section discusses the selection of exposure frequency based on EPA's default factors and best professional judgment. This section shall clarify and state what exposure frequencies were chosen.	<p>As described on p. 4-5 of this section, the exposure parameters are discussed in general terms in this section, and followed by more detailed explanations on the specific value and sources/justification for that value for specific receptors in section 4.2.</p> <p>The specific exposure frequency that will be used is included in Section 4.2.1.2.2 for receptors north of I-10, Section 4.2.2.2 for trespassers south of I-10, and Section 4.2.2.3 for workers south of I-10.</p>
17	4.1	4-6	This section discusses the selection of exposure duration based on EPA's default factors and best professional judgment. This section shall clarify and state what exposure durations were chosen.	<p>As described on p. 4-5 of this section, the exposure parameters are discussed in general terms in this section, and followed by more detailed explanations on the specific value and sources/justification for that value for specific receptors in Section 4.2.</p> <p>The specific exposure durations to be used are included in Section 4.2.1.2.1 for receptors north of I-10, Section 4.2.2.2 for trespassers south of I-10, and Section 4.2.2.3 for workers south of I-10.</p>
18	4.1	4-8	EPA 2004 and 2011 are discussed as references for adherence factors for soil and sediment, but it is unclear which reference(s) were utilized in the final decision. This shall be stated as is done in other sections. This is apparent however, in Tables 8, 9, 10 and 11.	<p>As described on p. 4-5 of this section, the exposure parameters are discussed in general terms in this section, and followed by more detailed explanations on the specific value and sources/justification for that value for specific receptors in Section 4.2.</p> <p>The specific adherence factors and their references are included in Section 4.2.1.2.2 for receptors north of I-10, and Section 4.2.2.3 for workers south of I-10.</p> <p>A reference will be added for the factors proposed for the trespasser for the area south of I-10 in Section 4.2.2.2 in the final EA Memo.</p>

EPA Comments Relating to the Draft Exposure Assessment Memorandum, and Responses

Comment No.	Section	Page	Comment	Response to Comment - Proposed Revision
19	4.1	4-8	<p><b>Fractions of Total Pathway Exposure to Soil and to Sediment:</b> It is stated that " To estimate exposure, it is therefore necessary to describe the portion of the dermal exposure pathway that will be attributable to soil and sediment." The text shall include that description.</p> <p>In addition, it was stated that "Information about the activities each receptor may engage in at the Site was used to assign these fractions." The text shall also provide information about these activities and how they were used to assign the fractions.</p>	<p>As described on p. 4-5 of this section, the exposure parameters are discussed in general terms in this section, and followed by more detailed explanations on the specific value and sources/justification for that value for specific receptors in Section 4.2.</p> <p>Text describing the factors considered in determining this fractional term are included in Sections 4.2.1.1 and 4.2.1.2.2. Clarification that the factors are based on professional judgment regarding the manner in which receptors are conceptualized to interact with soils and sediments will be provided in Section 4.2.1.1 of the EA Memo.</p>
20	4.1	4-9	<p><b>Fraction of Total Daily Intake from Soil/Sediment That Is Site-Related:</b> It was stated that "Information about the Site was considered when determining the value for this factor for each receptor." The text shall provide that information.</p>	<p>As described on p. 4-5 of this section, the exposure parameters are discussed in general terms in this section, and followed by more detailed explanations on the specific value and sources/justification for that value for specific receptors in Section 4.2.</p> <p>Text describing the information that was considered for determining the factor for each receptor and exposure medium is in Section 4.2.</p>
21	4.1	4-9	<p><b>Fraction of Total Fish or Shellfish Intake That Is Site-Related:</b> It is stated that, "Information about the Site was considered when determining this factor." The text shall provide that information.</p>	<p>As described on p. 4-5 of this section, the exposure parameters are discussed in general terms in this section, and followed by more detailed explanations on the specific value and sources/justification for that value for specific receptors in Section 4.2.</p> <p>Text describing the information that was considered for determining the factor for each receptor and exposure medium is in Section 4.2.1.2.3.</p>
22	4.2.1.1	4-11	<p>This paragraph states that "Information regarding fishing activities and consumption patterns at the Site is not available. In the absence of specific information on diet, exposures will be estimated separately under three scenarios: one scenario will consider finfish ingestion only, a second will consider crab ingestion only, and a third will consider clam ingestion only." Given the lack of site-specific information on fishing activities, this is a reasonable approach. However, to help reduce the expected uncertainty, scenarios shall be included that examine the possibility of exposure which does combine two or three of the fish, crab or clam.</p>	<p>Section 4.2.1.1 states that additional scenarios that include a mixed diet of two or more tissue types will be included in the uncertainty evaluation. Because of the absence of site-specific data on the composition of the diets of people who might collect seafood for consumption at the site, evaluation of a specific dietary scenario would be speculative. Focusing the risk assessment on single-tissue type exposures helps to quantify the types of tissues that are likely to result in the highest potential for exposure and simplifies calculation of an acceptable risk-based concentration in each tissue type. Evaluating a mixed diet in the uncertainty section helps frame each estimate of an acceptable concentration derived using single-tissue type diets.</p> <p>Clarification on the conservative nature of calculating risks associated with single tissue type diets that will be clarified in this section in the final EA Memo.</p>
23	Table 7		<p>Figure 1 denotes a Trespasser scenario for the northern impoundment. Such scenario shall also be included in Table 7.</p>	<p>Table 7 defines the scenarios that will be evaluated quantitatively in the risk assessment. Exposure pathways for the trespasser north of I-10 are considered potentially complete but minor, so the north impoundment Trespasser exposure and risk will be presented qualitatively and will therefore not be added to Table 7 (please see response to Comment 1).</p>

**Notes**

a – Original Comment 6 was withdrawn per a communication from Gary Miller, U.S. EPA, to David Keith, Anchor QEA, LLC, dated May 10, 2012, and has been omitted from this response to comments. Original comment numbers on subsequent comments are retained herein.

**References**

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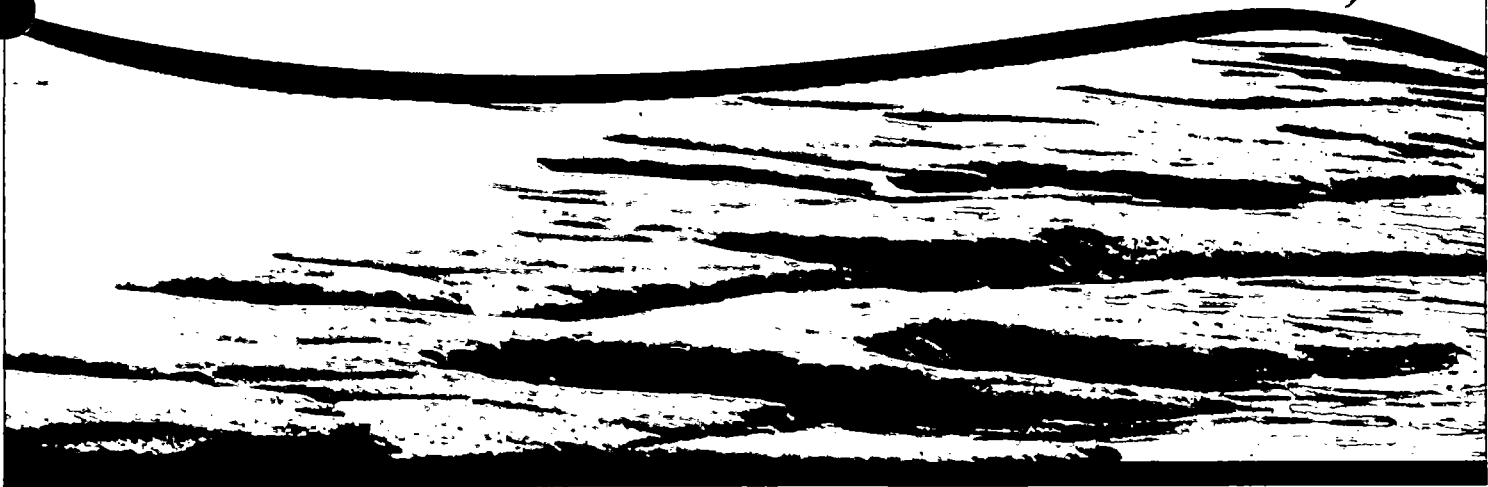
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APPENDIX B  
TOXICOLOGICAL AND  
EPIDEMIOLOGICAL STUDIES  
MEMORANDUM

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## TOXICOLOGICAL AND EPIDEMIOLOGICAL STUDIES MEMORANDUM SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

### **Prepared for**

McGinnes Industrial Maintenance Corporation  
International Paper Company  
U.S. Environmental Protection Agency, Region 6

### **Prepared by**

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411 1st Avenue S, Suite 550  
Seattle, Washington 98104

**May 2012**

# TOXICOLOGICAL AND EPIDEMIOLOGICAL STUDIES MEMORANDUM SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

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**Prepared for**

McGinnes Industrial Maintenance Corporation  
International Paper Company  
U.S. Environmental Protection Agency, Region 6

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**May 2012**

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## List of Acronyms and Abbreviations

Abbreviation	Definition
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
ADI	allowable daily intake
AhR	aryl hydrocarbon receptor
ARNT	aryl hydrocarbon receptor nuclear translocator
ATSDR	Agency for Toxic Substances and Disease Registry
BEHP	bis(2-ethylhexyl)phthalate
BHHRA	baseline human health risk assessment
BMD	benchmark dose modeling
BMDL	benchmark dose lower limit
BMR	benchmark response
CalEPA	California Environmental Protection Agency
COPC	chemical of potential concern
COPC <sub>H</sub>	chemical of potential concern to be addressed in the baseline human health risk assessment
CSF	cancer slope factor
CSM	conceptual site model
DLC	dioxin-like compound
DMA	dimethylarsinic acid
DWEL	Drinking Water Exposure Level
EHMI	equivalent human monthly intake
HEAST	Health Effects Assessment Summary Tables
IPC	International Paper Company
IPCS	International Programme on Chemical Safety
IRIS	Integrated Risk Information System
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LALC	lifetime average liver concentration
LASC	lipid-adjusted serum concentration
LOAEL	lowest-observed-adverse-effects level
LOEL	lowest-observed-effects level
MIMC	McGinnes Industrial Maintenance Corporation

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MMA	monomethylarsonic acid
MOA	mode of action
MRL	minimal risk level
NAS	National Academies of Science
NOAEL	no-observed-adverse-effects level
NOEL	no-observed-effects level
NTP	National Toxicology Program
OEHHA	Office of Environmental Health Hazard Assessment
PBPK	physiologically based pharmacokinetic (modeling)
PCB	polychlorinated biphenyl
POD	point of departure
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	Preliminary Remediation Goal
ppt	parts per trillion
PTMI	provisional tolerable monthly intake
REP	relative effect potency
RfD	reference dose
RI/FS	Remedial Investigation and Feasibility Study
SAB	Science Advisory Board
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits site in Harris County, Texas
SJRWP	San Jacinto River Waste Pits
TDI	tolerable daily intake
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TEQ <sub>DF</sub>	toxicity equivalent for dioxins and furans
TEQ <sub>DFP</sub>	cumulative toxicity equivalent for PCBs and dioxins and furans
TEQ <sub>P</sub>	toxicity equivalent for polychlorinated biphenyls
TESM	Toxicological and Epidemiological Studies Memorandum
TMI	tolerable monthly intake
TSH	thyroid-stimulating hormone
UAO	Unilateral Administrative Order
UF	uncertainty factor

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USEPA	U.S. Environmental Protection Agency
WHO	World Health Organization
WOE	weight of evidence

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## 1 INTRODUCTION

This technical memorandum has been prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC; collectively referred to as the Respondents). It has been completed in fulfillment of the 2009 Unilateral Administrative Order (2009 UAO), Docket No. 06-03-10, issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009 (USEPA 2009a), for the San Jacinto River Waste Pits (SJRWPs) site in Harris County, Texas (the Site).

The 2009 UAO directs the Respondents to perform a Remedial Investigation and Feasibility Study (RI/FS) for the Site, and indicates that the remedial investigation shall include a baseline human health risk assessment (BHHRA). The UAO also directs respondents to prepare a Toxicological and Epidemiological Studies Memorandum (TESM) prior to the BHHRA report to present toxicological and epidemiological studies that will be used to perform the toxicity assessment. The TESM is to specify the toxicological criteria that will be used in the BHHRA to evaluate potential risks and hazards associated with exposure to chemicals of potential concern (COPCs) at the Site. Toxicity criteria include cancer slope factors (CSFs) for evaluating potential cancer effects for COPCs assumed to have a linear mode of action, and reference doses (RfDs) for evaluating both noncancer health effects and cancer effects for COPCs assumed to have a nonlinear mode of action (USEPA 2012a).<sup>1</sup>

This document fulfills the UAO requirement for a TESM, building on the results of the Chemicals of Potential Concern (COPC) Technical Memorandum (Integral 2011a), which identified the final list of COPCs to be evaluated in the BHHRA (referred to herein as COPCHs). The specific topics addressed by this TESM include:

- The general approach for selecting carcinogenic and non-carcinogenic toxicological criteria
- The toxicological endpoints of concern for each of the COPCHs

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<sup>1</sup> Different regulatory agencies use different terms for this “safe” dose. USEPA has historically used the terms “reference dose” (RfD) or “allowable daily intake” (ADI). ATSDR uses the term “minimal risk level” (MRL). Canada and many international regulatory agencies use the term “tolerable daily intake” (TDI). In general, these terms are interchangeable and represent a threshold dose at which no adverse effects are expected to occur.

- The toxicological criteria selected for each COPCH and the rationale for their selection.

## **1.1 Purpose**

This memorandum is intended to establish the toxicological criteria to be used in evaluating potential risks and hazards associated with the Site. These toxicological criteria will be used for conducting the BHHRA. USEPA comments on this draft TESH will be incorporated into a final TESH, which will ultimately be provided as an appendix to the draft BHHRA, which is scheduled to be delivered to USEPA in July 2012. The selected toxicological criteria will be combined with the intake estimates to derive estimated risks and hazards at the Site.

## **1.2 Document Organization**

This document is organized as follows:

- Section 2. Site-related background
- Section 3. Approach to selection of toxicological criteria
- Section 4. Toxicological criteria for organic compounds
- Section 5. Toxicological criteria for metals
- Section 6. Evaluation of uncertainty in selected criteria
- Section 7. References.

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## 2 SITE-RELATED BACKGROUND

To provide context for the identification and selection of toxicological criteria to be used in the BHHRA, this section provides a brief overview of the COPCHS and the types of exposure that may occur at the Site. These COPCHS and exposures have been developed on the basis of information provided in the COPC Technical Memorandum (Integral 2011a), the RI/FS Work Plan (Anchor QEA and Integral 2010a), the Sampling and Analysis Plans (SAPs) for sediment, soil, and tissue (Integral and Anchor QEA 2010, Integral 2010a,b) and the Preliminary Site Characterization Report (PSCR) (Integral and Anchor QEA 2012), all of which have been previously submitted to, and approved by, USEPA. Details on the specific receptors, exposure scenarios, and exposure parameters and assumptions to be used in the BHHRA are provided in the Draft Exposure Assessment Memorandum, which is being submitted concurrently with this TESM (Integral 2012).

### 2.1 Chemicals of Potential Concern

COPCs have been identified according to steps described by the RI/FS Work Plan (Anchor QEA and Integral 2010a) and the Sediment SAP (Integral and Anchor QEA 2010). As documented in the COPC Technical Memorandum (Integral 2011a), analyses of the sediment data collected for the remedial investigation according to methods described in the Sediment SAP resulted in determination of the final list of COPCHS for the impoundments north of the I-10 and aquatic environment (Table 1).

Selection of COPCHS for the south impoundment area is in progress. According to a comparison of the Phase I soil investigation results to risk-based human health screening levels protective of workers, only the toxicity equivalent for dioxins and furans (TEQ<sub>DF</sub>), arsenic, and thallium exceed screening concentrations in any of the surface and subsurface soil samples in the south impoundment soils in which they were analyzed (Integral 2011c). Although thallium is not a COPCH according to analyses of information for the north impoundment, it may be determined upon the results of additional sampling to be a COPCH for the south impoundment, and is therefore addressed in this memorandum and listed in Table 1. Any chemicals in addition to those in Table 1 that become COPCHS for the south impoundment will be addressed in an attachment to the final TESM, which will be an appendix to the BHHRA report.

## **2.2 Types of Exposure**

As described in the approved RI/FS Work Plan (Anchor QEA and Integral 2010a), exposure pathways that are potentially complete and significant will be evaluated quantitatively in the BHHRA. Related exposure routes include ingestion of fish and shellfish and direct contact (ingestion and dermal) with soils and sediments, as appropriate, for the identified exposure scenarios. Therefore, toxicological criteria that relate exposure via these routes to adverse health effects are required.

Fishers, recreational visitors, and trespassers were identified in the conceptual site model (CSM) as the receptors with potentially complete exposure pathways in the impoundments north of I-10 and aquatic environments (Integral and Anchor QEA 2010), and trespassers and workers were identified as relevant human receptors in the south impoundment area (Integral 2011b). The CSM diagrams, which provide an overview of the potentially complete pathways identified for these receptors in the impoundments north of I-10 and aquatic environments, and the south impoundment area, are included as Figures 1 and 2, respectively.

A more detailed discussion of exposure pathways and routes to be evaluated for the BHHRA, and the specific methods for evaluation, is provided in the Exposure Assessment Memorandum (Integral 2012).

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### 3 APPROACH TO SELECTION OF TOXICOLOGICAL CRITERIA

Toxicological criteria are numerical expressions of chemical dose and response. In a BHHRA, toxicological criteria for each of the COPCHS are used along with site-specific estimates of exposures to develop estimates of potential risks and/or hazards. Some COPCHS are considered to cause both cancer and noncancer health effects and therefore can have toxicological criteria for both endpoints. For those COPCHS that are considered to have the potential to cause cancer (carcinogenic), toxicological criteria are developed using toxicological studies in which either tumors were an outcome or precursors to tumorigenicity were observed. For COPCHS that are considered to have the potential to cause noncancer health effects, toxicological criteria are based on the adverse health effect elicited at the lowest doses. For either type, the dose level at which no adverse effects are observed, or the lowest dose tested at which adverse effects are observed, is the point of departure (POD) for developing toxicological criteria. Ultimately, for a chemical eliciting noncancer effects, or eliciting cancer effects that are expected to have a threshold dose (an exposure level below which no adverse effects are expected), the toxicological criterion is the dose level at which no adverse health effects are expected to occur. For chemicals assumed to have no threshold dose in causing cancer effects, dose response is assumed to be linear and a modeled CSF is the toxicological criterion used to identify cancer risks associated with specific levels of exposure.

Toxicological criteria may differ depending on the length of human exposure. USEPA defines acute exposures as lasting less than 2 weeks (USEPA 1989a). Subchronic exposures are defined as lasting for at least 2 weeks but less than 7 years, and chronic exposures are defined as lasting 7 years or more.

The majority of the exposure scenarios to be evaluated in the BHHRA will be long-term (chronic). For these scenarios, chronic toxicological criteria will be used. There are, however, some potential exposure scenarios, such as the trespasser scenario in the south impoundment area, that are anticipated to occur for more than 2 weeks but less than 7 years. When exposure durations of less than 7 years are anticipated, subchronic toxicological criteria will be used, if available.

Toxicological criteria may also differ depending upon the route of exposure. For example, criteria for both cancer and noncancer effects may be specifically derived for the dermal, ingestion, or inhalation exposure routes. As discussed in the CSM (Anchor QEA and Integral 2010a), only the dermal and ingestion routes are considered complete and significant for the BHHRA for this Site. As a result, only toxicological criteria for these routes are presented in the TESM. While dermal-specific toxicological criteria are available for some chemicals, there are no dermal-specific toxicological criteria available for the COPCHs. Thus, the oral criteria will be used to evaluate toxicity for both the oral and dermal routes of exposure, with appropriate adjustments for absorption efficiency by the dermal route, as outlined in USEPA (1989a, 2004a) guidance.

A general discussion of cancer and noncancer toxicological criteria and the hierarchy of sources that have been consulted for the selection of toxicological criteria for the BHHRA are provided below. The COPCH-specific toxicological criteria for cancer and noncancer effects are presented in Sections 4 and 5.

### 3.1 Cancer Effects

USEPA evaluates the potential for individual chemicals to cause cancer in humans. An initial step in this evaluation is the completion of a qualitative, weight-of-evidence (WOE) evaluation of the extent to which a chemical is believed to be a human carcinogen. A chemical is assigned a WOE classification based on data obtained from both human and animal studies as follows:

- Chemicals for which USEPA considers there to be adequate causal evidence of carcinogenicity in humans (generally based on human epidemiological data) are categorized as “known human carcinogens” (WOE Class A).
- Other chemicals with various levels of supporting data may be classified as “probable human carcinogens” (WOE Classes B1 or B2), or “possible human carcinogens” (WOE Class C).
- If USEPA considers the available data to be inadequate for determining carcinogenicity, the chemical is identified as “not classifiable as to human carcinogenicity” (WOE Class D).

- When toxicological studies provide specific evidence of noncarcinogenicity, the chemical is assigned a WOE Class E.<sup>2</sup>

To assess the potential carcinogenic health effects from oral and dermal exposures, USEPA typically develops CSFs. CSFs are upper-bound estimates of the carcinogenic potency of chemicals. They are used to estimate the incremental risk of developing cancer, corresponding to a lifetime of exposure at the levels estimated in the exposure assessment. In USEPA's standard, default risk assessment procedures, estimates of carcinogenic potency reflect the conservative assumption that there is no threshold dose for carcinogenic effects, that is, there is no entirely "safe" dose and exposure to any amount of the chemical will contribute to an individual's overall risk of developing cancer during a lifetime.

USEPA's *Guidelines for Carcinogen Risk Assessment* (2005a), however, recognizes that some carcinogens act in a manner within the body (i.e., a mode of action) that follows a nonlinear, threshold response. A nonlinear dose-response relationship is one in which a level of exposure exists at which there is no increased risk of cancer within the exposed population so that only exposure levels that exceed a threshold dose will result in an increased risk of cancer. USEPA allows for estimates of carcinogenic potency to be based on a non-linear model when sufficient evidence exists to support a non-linear mode of action for the general population and any subpopulations of concern (USEPA 2005a).

### 3.2 Noncancer Effects

To evaluate potential noncancer health effects that may result from exposure to COPCHS, the potential hazard is evaluated by comparing the estimated daily intake with an RfD or other estimate of a safe daily dose. For long-term exposures, this is identified as a chronic RfD. USEPA (1989a) defines the chronic RfD as a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Subchronic RfDs represent average daily exposure

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<sup>2</sup> The WOE approach outlined in the final *Guidelines for Carcinogen Risk Assessment* (USEPA 2005a) differs from and may eventually supersede the categories currently used in USEPA's Integrated Risk Information System (IRIS). The outlined approach considers all scientific information in determining whether and under what conditions an agent may cause cancer in humans, and provides a narrative approach to characterize carcinogenicity rather than categories.

levels at which no adverse health effects are expected to occur with subchronic exposures of less than 7 years, as would be the case for the trespasser scenarios to be evaluated for this Site. RfDs reflect the underlying assumption that systemic toxicity occurs as a result of processes that have a threshold (i.e., that a safe level of exposure exists and that toxic effects will not occur until this level has been exceeded).

The RfDs for noncarcinogenic effects are generally derived on the basis of laboratory animal studies or epidemiological studies (i.e., studies of humans). In such studies, the RfD is typically calculated by first identifying the highest concentration or dose that does not cause observable adverse effects (the no-observed-adverse-effects level, or NOAEL) in the study. If a NOAEL cannot be identified from the study, the lowest-observed-adverse-effects level (LOAEL) may be used. This dose or concentration is then divided by uncertainty and/or modifying factors to calculate an RfD.

When deriving an RfD, uncertainty and modifying factors may be applied to account for limitations of the underlying data. Uncertainty factors are intended to provide a margin of safety to ensure that exposures resulting in actual doses less than or equal to the RfD will be unlikely to result in adverse health effects in exposed human populations. Standard uncertainty factors include those that account for uncertainties stemming from extrapolating doses and effects from animal studies to humans; accounting for variation in sensitivity among members of the human population; using a LOAEL instead of a NOAEL; using data from subchronic studies to derive chronic toxicological criteria; and using a limited or incomplete database (e.g., some effect endpoints are untested) for the chemical. Uncertainty factors are most commonly factors of 10. There are many times, however, when a full factor of 10 is not warranted. When this occurs, a factor of 3 (at one significant figure) or 3.2, which is the square root of 10, is sometimes used. Modifying factors, which are variable in magnitude, account for uncertainties and variabilities that are not captured by the standard uncertainty factors described above.

Once the appropriate uncertainty and modifying factors are used to adjust the NOAEL or LOAEL from the toxicological study, the recommended toxicological criteria are presented in USEPA's Integrated Risk Information System (IRIS) and other regulatory databases. These criteria are then directly compared with estimated exposures to estimate potential hazards.

### 3.3 Selection of COPC<sub>H</sub>-Specific Toxicological Criteria

USEPA has outlined a hierarchy of sources to be considered in selecting toxicological criteria (USEPA 2003a). In accordance with USEPA's hierarchy, the toxicological sources considered in selecting toxicological criteria, in order of preference, are:

- Tier 1: USEPA's IRIS<sup>3</sup>
- Tier 2: USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) from the National Center for Environmental Assessment/Superfund Health Risk Technical Support Center<sup>4</sup>
- Tier 3: Other USEPA and non-USEPA sources, such as the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs)<sup>5</sup>, USEPA's Health Effects Assessment Summary Tables (HEAST; USEPA 1997), California EPA (CalEPA) values,<sup>6</sup> and other sources that are current, publicly available, and have been peer reviewed.

While these sources generally provide information on toxicological criteria to be used in evaluating long-term chronic exposures, information on subchronic exposures is generally more limited. USEPA's IRIS database has limited toxicity information to evaluate subchronic exposures. However, in many cases, the chronic toxicological criteria that have been developed by USEPA are based on less-than-lifetime studies and an uncertainty factor has been included in the calculation of the chronic RfD to estimate a long-term toxicity value from a study with short-term exposure. In addition, ATSDR commonly derives intermediate MRLs that are intended to evaluate exposures that are less than 1 year in duration.

In selecting subchronic toxicological criteria for the SJRWP BHHRA, the following approach was used: 1) if a subchronic value is available in the IRIS database, that value was selected; 2) if the chronic RfD is based on a subchronic study, and an uncertainty factor has been used to adjust for study duration, that uncertainty factor is removed to derive a subchronic RfD; and 3) if IRIS has no subchronic RfD and the chronic RfD is not based on a subchronic study, then

<sup>3</sup> Available at: <http://www.epa.gov/ncea/iris/>.

<sup>4</sup> Values available at: <http://hhpprtv.ornl.gov/>

<sup>5</sup> Available at: <http://www.atsdr.cdc.gov/mrls/index.asp>

<sup>6</sup> Available at: [http://www.oehha.ca.gov/air/hot\\_spots/tsd052909.html](http://www.oehha.ca.gov/air/hot_spots/tsd052909.html)

ATSDR's intermediate MRL was selected as the toxicity criterion to evaluate subchronic exposures.

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## 4 TOXICOLOGICAL CRITERIA FOR ORGANIC COMPOUNDS

This section presents the specific toxicological criteria that will be used to evaluate the toxicity of organic COPCHS at the Site. The studies upon which these criteria are based are discussed for each COPCH. Recommended toxicological criteria for cancer and noncancer effects are summarized in Tables 2 and 3, respectively.

### 4.1 Dioxins and Furans

USEPA has been conducting an assessment of dioxin risks (the “dioxin reassessment”) for nearly 20 years but this process is only partially complete. During this period, there has been extensive, worldwide evaluation of the toxicological literature for dioxins and furans, and substantial disagreement remains within the scientific community as to the appropriate approach for estimating the toxicity potential of dioxins, furans, and related compounds. Much of the scientific disagreement revolves around the mode of action of these compounds and whether or not they demonstrate a threshold for carcinogenic effects. USEPA recently finalized its noncancer toxicity criterion for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and published it in its IRIS database, thereby providing a Tier 1 toxicity criterion for evaluation of noncancer endpoints. However, USEPA’s evaluation of the appropriate approach for estimating the carcinogenic potential of TCDD is ongoing. Because there is no Tier 1 or Tier 2 criterion available to evaluate the potential carcinogenic effects of TCDD and related chemicals, it is necessary to consider Tier 3 sources in selecting a cancer-based criterion for use in the BHHRA. The available Tier 3 values vary widely in both magnitude and approach.

This section first discusses the use of toxicity equivalency factors (TEFs), which relates to the mechanism of action by which these compounds are believed to act, the various ways in which regulatory agencies throughout the world have evaluated their toxicity, and the relative potency of individual dioxins, furans, and “dioxin-like” polychlorinated biphenyl (PCB) congeners. The discussion of TEFs and their basis also addresses certain PCB congeners because they are thought to act through a mechanism of action common to that of dioxins and furans. This section then discusses background information on the history of the regulatory process for developing quantitative estimates of the toxicity of dioxins, furans, and related “dioxin-like compounds” (DLCs). Finally, this section presents the toxicological

criteria selected for evaluation of cancer and noncancer risks for the Site, placing the selection of the criteria in the broader technical and regulatory context.

#### **4.1.1 Toxicity Equivalency Factors**

In all, there are 75 dioxins and 135 furans that are differentiated by the numbers and positions of the chlorine atoms present. Seventeen of those congeners have chlorine substitutions in the 2,3,7,8-positions of the molecule. It is widely believed that toxicity of these 17 congeners occurs through a common biochemical mechanism, one that is initiated by the binding of the congener to the aryl hydrocarbon receptor (AhR), and that interactions of these congeners with AhR leads to alterations in gene expression and signal transduction that are believed to be the biochemical determinants of toxic effects (Birnbaum 1994). AhR is a member of a family of transcription factors that includes aryl hydrocarbon receptor nuclear translocators (e.g., ARNT). These proteins are involved in the sensation of and adaptation to changing environmental and developmental conditions. Once activated, AhR combines with ARNT and moves into the cell nucleus, where the complex can then bind specific DNA sequences, leading to altered gene expression. A role of the ligand-AhR complex in non-nuclear signal transduction has also been proposed.

Of the 17 AhR-active congeners, TCDD exhibits the greatest potential for binding with AhR. The common toxicological mechanism among the 17 congeners provides the basis for calculating the cumulative exposure to all AhR-active congeners for the purposes of evaluating toxicity.

Under the TEF approach, the magnitude of toxicity of each of these 17 dioxin and furan congeners is related to the toxicity of TCDD using a congener-specific TEF. The concentration of each congener is converted to an equivalent concentration of TCDD by multiplying the concentration of the congener by its TEF to derive a toxicity equivalent (TEQ) concentration for that congener. The congener-specific TEQs are then added together to compute the total TEQ concentration of the mixture of dioxins and furans (i.e., TEQ<sub>DF</sub>). The resulting TEQ<sub>DF</sub> concentration provides the metric to be used in evaluating exposure to the mixture.

The toxic equivalency approach was first developed in 1977 for screening risks from dioxins and furans in combustion sources and incinerator emissions (Eadon et al. 1986; Erickson 1997). It was intended for use as an “interim” screening tool to evaluate the toxicity of mixtures of dioxins and furans because many congeners lacked specific toxicity data. When the approach was initially applied in 1986, USEPA’s Science Advisory Board (SAB) supported its use as an interim approach, but noted that it might “lack scientific validity” and recommended that it be regularly revisited (USEPA 1989b). In 1989, USEPA stated that the TEQ approach “remains ‘interim’ in character and should be replaced as soon as practicable with a bioassay method” (USEPA 1989b).

The application of the TEQ approach to PCB congeners was introduced in 1991. Twelve of the 209 PCB congeners are considered to have dioxin-like toxicity because, like TCDD, they have a high affinity to bind to the AhR. As a result, the toxicity of these PCB congeners is considered to be additive with that of dioxins and furans expressed as TEQ (Safe 1990). TEFs for the 12 PCB congeners were assigned on the basis of a variety of endpoints demonstrated by *in vitro* assays and *in vivo* animal studies, most of which are noncancer endpoints (Van den Berg et al. 1998).

As for calculation of the  $TEQ_{DF}$ , to calculate the TEQ for PCB congeners ( $TEQ_P$ ), the concentrations of the individual dioxin-like PCB congeners within the PCB mixture are first converted to TEQ concentrations using the appropriate TEFs (Table 4) and the  $TEQ_s$  for the individual congeners are then summed to derive the TEQ for the mixture of the congeners ( $TEQ_P$ ). Once the  $TEQ_P$  concentration has been calculated, it can be added to  $TEQ_{DF}$  to determine a total TEQ concentration for dioxins, furans and the dioxin-like PCB congeners ( $TEQ_{DFP}$ ).

The toxicological basis and rationale for the use of the TEF approach is described in Van den Berg et al. (1998; 2006), and in USEPA’s Review Draft Dioxin Reassessment (USEPA 2003b). It has now been formally adopted by USEPA (2010a). The recommended TEFs for evaluating human health risks are provided in Table 4.

There are substantial uncertainties associated with the use of the TEQ approach. These are due largely to several simplifying assumptions used in developing the TEFs, including:

- The assumption that the dose response curves for different congeners and endpoints are parallel
- The assumption that the effects of multiple DLCs are additive
- The assumption that humans are as sensitive as laboratory animals to the effects of DLCs
- The assumption that noncancer endpoints and *in vitro* studies can be used to predict the carcinogenic potential of the individual DLCs.

In addition, for a subset of PCB congeners, the TEF values were derived by comparing the toxicity of those congeners with that of 3,3',4,4',5-pentachlorobiphenyl (PCB-126) to develop relative effect potencies (REP) (Haws et al. 2006) rather than through direct comparison with TCDD. When developing REP estimates in this way, the principle of transitivity was invoked; that is, by quantifying both the toxicity of a DLC relative to PCB-126 and PCB-126 relative to TCDD, one could estimate the toxicity of the DLC relative to TCDD (USEPA 2010a). The TEF for PCB-126 was set at 0.1. Consequently, the PCB-126-based REPs were multiplied by 0.1 in the derivation of TEFs for other congeners in order to relate them to TCDD (Van den Berg et al. 2006). Given that the TEFs are meant to measure relative toxicity within an order of magnitude, and that two-order-of-magnitude assumptions are being combined with this approach, this assumption could result in substantial over- or underestimation of actual toxicity of those PCB congeners.

Multiple studies have indicated that the assumptions underlying the TEQ approach are not well supported in the scientific literature (Van den Berg et al. 2006; Roberts et al. 1990; Ema et al. 1994; Poland et al. 1994; Ramadoss and Perdew 2004; NAS 2006; Haws et al. 2006; Wiebel et al. 1996; Xu et al. 2000; Zeiger et al. 2001; Connor and Aylward 2006; Vamvakas et al. 1996; Silkworth et al. 2005; Carlson et al. 2009; Harper et al. 1995; Safe 1990; Starr et al. 1997; Toyoshiba et al. 2004; Walker et al. 2005; USEPA 2010a; SAB 2011).

In addition, the use of TEFs in evaluating potential risks due to exposures to abiotic media, such as soil and sediment, is not recommended by the authors of the current TEFs unless the "aspect of reduced bioavailability is considered" (Van den Berg et al. 2006, p. 237). This is because use of the TEF approach to characterize exposure concentrations implies that all compounds have the same bioavailability as TCDD. However, there is little empirical

information available about the relative bioavailability of the individual DLCs when they are bound to abiotic media.

Despite these limitations, USEPA generally requires that the TEFs and the TEQ scheme be used to evaluate the risks due to mixtures of DLCs, regardless of the medium of exposure. This approach will be used to evaluate exposures to the dioxin/furan and PCB congeners in all media of interest at the Site. The uncertainties introduced to risk and hazard estimates by the use of this approach will be discussed in the BHHRA.

#### **4.1.2 History of Regulatory Process for Dioxins and Furans**

USEPA's historical regulatory activities related to TCDD have focused on its carcinogenic potential and the results of a rat bioassay conducted by Kociba et al. (1978), which demonstrated an increased incidence of hepatocellular and respiratory tumors in rats exposed to TCDD in their food. Based on the information available at that time, USEPA (1985) classified TCDD as a Class B2 (probable) carcinogen and derived a CSF of  $156,000 \text{ (mg/kg-day)}^{-1}$  using a non-threshold, linear dose response model<sup>7</sup> to estimate the potential for TCDD to cause cancer in humans at low environmental dose levels. This CSF has been widely used historically by USEPA and risk assessors to evaluate the potential carcinogenic effects of TCDD but has never been published in USEPA's IRIS database. A slightly different value of  $150,000 \text{ (mg/kg-day)}^{-1}$  was published in USEPA's Health Effects Assessment Summary Tables (USEPA 1997). There was no explanation, however, for this apparent discrepancy.

In 1991, USEPA announced that it would reassess the health risks associated with exposures to dioxin. It published the first external review draft of its reassessment of TCDD's health effects in 1994. Following SAB and expert panel reviews, USEPA revised and re-released its assessment in 2000, in which it proposed a CSF of  $1 \times 10^6 \text{ (mg/kg-day)}^{-1}$ . During its review of the revised 2000 draft, the SAB (USEPA 2001a) expressed concerns about the analyses and conclusions presented by USEPA on the carcinogenicity of TCDD. In response to the SAB comments, USEPA completed revisions to certain sections of the reassessment document in

<sup>7</sup> A linear dose response model is a model that assumes that the frequency or severity of a biological response varies proportionately with the dosage and that there is no dosage that is without some risk of harm.

2003 (USEPA 2003b, 2004b), but did not change the CSF of  $1 \times 10^6$  (mg/kg-day)<sup>-1</sup> that had been proposed in the 2000 reassessment or the approach used to develop it (USEPA 2003b).

Despite these revisions, the uncertainties and apparent limitations were significant enough to require further and broader expert review. Hence, the 2003 draft reassessment was reviewed by an expert committee from the National Research Council (NRC 2006) of the National Academies of Science (NAS), as recommended by the Interagency Work Group on Dioxin and backed by the White House Administration (IWP 2003; USEPA 2004b). This additional expert review was recommended because of both SAB and continued public concerns regarding the robustness of the risk estimates provided in USEPA's draft reassessment and the uncertainties associated with these estimates. The committee (known as the Committee on USEPA's Exposure and Human Health Reassessment of TCDD and Related Compounds) published its findings in the summer of 2006 (Committee 2006).

The scientific debate surrounding the assessment of TCDD's toxicity has been largely focused on the carcinogenic properties of TCDD. However, the available scientific literature also indicates that TCDD may be associated with the induction of other, noncancer health effects at low doses. Despite this, USEPA did not propose an RfD in its 2003 revision to its dioxin reassessment. Instead, it reported its prediction that if an RfD for TCDD was to be derived using the traditional approach for setting RfDs, it would likely be 1 to 3 orders of magnitude below current background intakes (USEPA 2003b).

USEPA's statement about the probable magnitude of a noncancer RfD was not consistent with the outcomes of analyses conducted by other health agencies worldwide. ATSDR, the World Health Organization (WHO), the Joint United Nations Food and Agriculture Organization, the European Commission Scientific Committee on Foods, the Japanese Ministry of Health and Welfare, and the Health Council of the Netherlands all derived dose-based quantitative health guidelines based on noncancer endpoints and chronic exposures that were at or above background levels (Pohl et al. 2002). These guidelines ranged from 1 to 4 pg/kg-day based on a number of different toxicological endpoints for TCDD and DLCs (DeRosa et al. 1999; Pohl et al. 2002). The underlying risk assessments for these various guidelines considered the entire toxicological database for DLCs and incorporated

uncertainty factors to ensure that resulting toxicological criteria would be protective of human health for both the cancer and noncancer endpoints.

In 2010, USEPA released its draft report titled *EPA's Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments* (USEPA 2010b; Reanalysis) in which it responded to some of the recommendations that had been made by the NAS related to the dose response assessment of TCDD and the lack of an RfD. USEPA's Reanalysis proposed an RfD of 0.7 pg/kg-day. This value was based on its analysis of noncancer endpoints in two epidemiological studies conducted in Seveso, Italy (Baccarelli et al. 2008; Mocarelli et al. 2008).

Comments provided to USEPA on the 2010 Reanalysis indicated that the lack of scientific consensus continued and that USEPA had not sufficiently addressed a number of the uncertainties and recommendations discussed by NAS, including:

- The use of a linear dose response model to estimate the carcinogenic potential of dioxin despite the potential for there to be a threshold for this endpoint
- The approaches used in developing both the proposed oral CSF and the proposed RfD
- The uncertainties associated with the toxic equivalency factors (TEFs) developed for other DLCs and their incorporation into risk assessments
- The variability and uncertainties associated with the proposed toxicological criteria.

USEPA has now finalized the noncancer RfD of 0.7 pg/kg-day. However, based on the comments received by USEPA on its draft reassessment and subsequent documents, substantial work remains before the carcinogenic dose response assessment for TCDD can be finalized. As a result, USEPA has bifurcated its reassessment. It published its noncancer dose response assessment for TCDD to its IRIS database in February 2012 but has delayed its carcinogenic dose response document to a later, as yet unspecified, date (USEPA 2011a).

#### **4.1.3 Toxicological Criteria for TCDD**

Because of the unresolved scientific and regulatory controversies described in the previous section, no cancer-based toxicological criteria for TCDD are available from Tier 1 or Tier 2 sources; therefore, following the hierarchy presented in Section 3.3, Tier 3 sources of cancer-

based toxicological criteria for TCDD were considered. A discussion of the sources considered and the value selected to evaluate the carcinogenic potential of TCDD and other DLCs in the BHHRA for the SJRWP are presented in Section 4.1.3.1. In addition, the recently published RfD for TCDD is discussed in Section 4.1.3.2.

#### 4.1.3.1 Cancer

The available Tier 3 values for the carcinogenic potential of TCDD can be broken into two categories. The first category includes those criteria that are based on the assumption that a CSF for TCDD should be derived using a linear dose response model, so that it is assumed that any dose, no matter how low, will result in some cancer risk. The second category includes those toxicological criteria that are based on the assumption that there is a threshold dose for TCDD's carcinogenic activity so that that this threshold must be reached before TCDD can exert a carcinogenic effect. The first type (linear [i.e., non-threshold]) of Tier 3 values includes the original CSF developed by USEPA (1985), the value presented in USEPA's 1997 HEAST (USEPA 1997), the value developed by the CalEPA, a more recent value developed by CalEPA for use in its drinking water criteria, and a linear-based CSF developed by Simon et al. (2009). The second type (nonlinear [i.e., threshold]) of Tier 3 values includes values that have been developed by WHO, the Joint Food and Agriculture Organization (FAO)/WHO Expert Committee on Food Additives (JECFA), and a nonlinear value developed by Simon et al. (2009). Each of these values is discussed below.

It should be noted that USEPA has also proposed a revised linear-based CSF for TCDD in its draft dioxin reassessment, but the peer review of that value and its scientific basis is ongoing and a final value has not yet been published. As a result, it does not fit the criteria established by USEPA for a Tier 3 value. It is, however, briefly discussed as it is possible that this value may eventually be adopted by USEPA and published in its IRIS database as a Tier 1 value.

##### 4.1.3.1.1 USEPA (1985)

In its *Health Assessment Document*, USEPA (1985) used a linear dose response model to develop an oral CSF for TCDD of  $156,000 \text{ (mg/kg-day)}^{-1}$ . This value was based on the combined incidence of nasal, palate, and lung carcinomas, and hyperplastic nodules and

carcinomas in the livers of female rats studied by Kociba et al. (1978). Using the histopathological analysis conducted by the study's authors and a multistage linearized dose response model, USEPA developed a CSF of 151,000 (mg/kg-day)<sup>-1</sup>. USEPA (1985) completed a second analysis using the same study and modeling approach but instead based it on the histopathological analysis conducted by Squire (1980) to develop a CSF of 161,000 (mg/kg-day)<sup>-1</sup>. The geometric mean of these two values, 156,000 (mg/kg-day)<sup>-1</sup> was then selected as the recommended CSF.

#### 4.1.3.1.2 HEAST

In 1997, USEPA's HEAST database (USEPA 1997) provided a CSF of 150,000 (mg/kg-day)<sup>-1</sup> for TCDD. This value was reported to be provisional and is similar to the value derived by USEPA in 1985 based on the Kociba et al. (1978) rat study and those authors' histopathological analysis. However, it did not exactly match that value and was also not the same as either value developed in USEPA's *Health Assessment Document* or the geometric mean value of 156,000 (mg/kg-day)<sup>-1</sup> previously recommended by USEPA (1987a). Nevertheless, this value has been frequently used by USEPA to develop estimated cancer risks (see for example USEPA 2005b).

#### 4.1.3.1.3 CalEPA

In 1986, CalEPA reviewed the available data and completed multiple analyses. It calculated CSF values using the same tumor incidence data from the Kociba et al. (1978) rat study (including both the Kociba and Squire histopathology analyses) and the data provided by a National Toxicology Program (NTP) mouse bioassay (NTP 1982a). After fitting multiple datasets to a linearized multistage model, CalEPA determined that the highest CSF occurred when the NTP (1982a) data were used. This resulted in a CSF of 130,000 (mg/kg-day)<sup>-1</sup> (CalEPA 1986). It was based on the incidence of liver tumors in male mice, which CalEPA determined to be the most sensitive species, sex, and target organ. The value was derived by converting animal doses to human doses using body weight scaling, and fitting a linearized multistage model to the data for hepatic adenomas and carcinomas in male mice, as reported in that study. This CSF was peer-reviewed by a scientific review panel before it was adopted.

Subsequently, the California Office of Environmental Health Hazard Assessment (OEHHA 2007) proposed an alternative value of 26,000 (mg/kg-day)<sup>-1</sup> in 2007, based on the results of a more recent NTP (2006) study. This value was used in deriving drinking water criteria even though the previous value of 130,000 (mg/kg-day)<sup>-1</sup> is still presented on the CalEPA web site.<sup>8</sup> Despite the availability of this newer value, USEPA (2011b) has used the older CSF as the basis for its Regional Screening Levels for TCDD,<sup>9</sup> rather than its own, historical values of 156,000 or 150,000 (mg/kg-day)<sup>-1</sup>. While no rationale for the preferential selection of the CalEPA value is provided in the documentation on USEPA's web site, comments received from USEPA (Appendix A) state that the older CalEPA value was selected due to "the level of peer review as determined by the EPA's Regional Screening Levels Work Group."

#### 4.1.3.1.4 Simon et al. (2009)

Simon et al. (2009) used two approaches to derive cancer potency estimates based on a 2-year rat bioassay conducted by NTP (2006). The NTP study evaluated the carcinogenic potency of both mixtures of DLCs and individual compounds including TCDD. The study was well designed to include six dosing groups, measurements of both tissue concentrations and enzyme activity levels at different time points, and sacrifices of animals during the study to refine the dose-response assessment. NTP concluded that, based on increased incidences of cholangiocarcinomas and cellular adenomas of the liver, gingival squamous cell carcinomas, and cystic keratinizing epithelioma of the lung, there was evidence of carcinogenesis in female Sprague Dawley rats.

This study design allowed Simon et al. to conduct an analysis of cancer potency on the basis of internal dose, thereby considering interspecies differences in toxicokinetics and mode of action (MOA) in selecting their POD. Despite their concerns that rodent liver tumors may not be relevant to human health risk assessment, Simon et al. (2009) used the combined incidence of liver tumors as the endpoint for their evaluation, in recognition that these types of tumors have historically been used by USEPA in its cancer risk assessments for dioxin.

<sup>8</sup> [http://www.oehha.ca.gov/air/hot\\_spots/tsd052909.html](http://www.oehha.ca.gov/air/hot_spots/tsd052909.html). It is not clear whether OEHHA intends to update its previous value to be consistent with the value used for developing drinking water criteria. Both values appear on its web site, and attempts to contact toxicologists at OEHHA to clarify this have been unsuccessful.

<sup>9</sup> [http://www.epa.gov/reg3hwmd/risk/human/rb-concentration\\_table/Generic\\_Tables/index.htm](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm)

Simon et al. (2009) used the lifetime average liver concentration (LALC) as the dose metric that was most relevant to the development of liver tumors. Benchmark dose modeling (BMD) was conducted to identify the dose response relationship between the tumor incidence and the LALC. The authors then selected a benchmark response (BMR) of 1 percent to obtain liver concentrations to be used as the POD. This information was used to develop both linear and nonlinear extrapolations of the cancer potency of TCDD. This is an updated approach that reflects current thinking on evaluating toxicity of DLCs (WHO-IPCS 2008) and is consistent with USEPA (2006) guidance.

The LALC was estimated in the rats using the model developed by Aylward et al. (2005a,b) and Carrier et al. (1995a,b). This model was also used to determine the human equivalent doses based on the human liver concentrations that corresponded to the rat liver concentrations at the identified POD, thereby estimating the external human dose in a manner consistent with guidance developed by USEPA (2006) and WHO-IPCS (2008).

To complete the linear extrapolation, the lower confidence limit of the human equivalent dose was back-extrapolated, using the Aylward/Carrier model, from the lower confidence limit of the benchmark dose tissue concentration in the rats. The cancer potency factors were then calculated from the POD value, by calculating the ratio between the BMR of 1 percent and the POD. While both the dichotomous Hill model and the multistage model were used, the authors preferred the dichotomous Hill model because they considered it to be more consistent with the receptor-mediated toxicity. They concluded that the CSF of  $100,000 \text{ (mg/kg-day)}^{-1}$  was the most appropriate value derived from the linear extrapolations.

To calculate the nonlinear dose response, the potency was calculated as the ratio between the BMD at the chosen POD and then additional extrapolation and adjustment factors were incorporated to account for interspecies variability and differences in sensitivity within the human population. This yielded an RfD for the cancer endpoint of 100 pg/kg-day.

This peer-reviewed study integrated USEPA's (2005a) guidance on carcinogen dose-response with the most current cancer bioassay data available from NTP (2006). It was consistent with the recommendations made by USEPA's SAB (2001) and NAS (2006) in that it included use of a nonlinear approach, accounted for differences in toxicokinetics in rats and humans,

considered internal dose metrics, and quantified the uncertainties associated with each choice made. While Simon stated that the use of the nonlinear (threshold) RfD of 100 pg/kg-day as the most appropriate metric of cancer potency, due to the known MOA of TCDD, these authors also recognized USEPA's preference for the use of a linearized model and developed an alternative CSF of 100,000 (mg/kg-day)<sup>-1</sup> using that approach.

#### 4.1.3.1.5 WHO

WHO has used a nonlinear (threshold) approach to develop a tolerable daily intake (TDI) that is protective of both cancer and noncancer endpoints. WHO (1991, 1992) reviewed the available data for TCDD and concluded that it was carcinogenic in animals. WHO developed a TDI based on liver, immunological, and reproductive effects in animals, which it believed to be the most sensitive endpoints, and established a no effect level of approximately 1,000 pg/kg-day. WHO then adjusted that dose by a factor of 10 to derive an equivalent human dose level of 100 pg/kg-day and applied an additional uncertainty factor of 10 to account for the lack of sufficient data on reproductive effects in humans. This resulted in an estimated TDI of 10 pg/kg-day.

Subsequently, WHO (1998), in concert with the International Programme on Chemical Safety (IPCS), completed a reassessment of the toxicity of TCDD and concluded that the most sensitive noncancer effects included developmental and reproductive effects observed in studies of rats and monkeys. They concluded that the most appropriate measure of exposure is tissue burden, rather than ingested dose. Thus, they identified the tissue burden effect levels and concluded that the LOAEL tissue burdens ranged from 28 to 73 ng/kg. They then used a steady state pharmacokinetic model to calculate a TDI that would result in that tissue burden range, estimated to be between 14 and 37 pg/kg-day. Finally, they used an uncertainty factor of 10 to address the uncertainties associated with the use of LOAELs, rather than no effect levels, potential interspecies differences, potential differences in sensitivity within the human population, and the differences in half-lives of elimination of compounds of a complex TEQ mixture. This resulted in a TDI range of 1 to 4 pg/kg-day that was established to be protective of all endpoints, including cancer. This TDI was developed by a panel of experts. As a result, USEPA (2010b) considers this value to have been adequately peer-reviewed.

#### 4.1.3.1.6 JECFA

JECFA (2002) also derived a TDI based on body burden. This committee included individuals from the U.S. Food and Drug Administration (USA), Health Canada (Canada), the National Institute of Public Health and the Environment (Netherlands), Municipal Institute of Medical Research (Spain), Chemisches und Veterinäruntersuchungsamt (Germany), Scientific Directorate on Human Nutrition and Food Safety of the National Institute for Agricultural Research (France), Center for Risk Management (USA), and the National Institute of Public Health and the Environment (Netherlands). These individuals reviewed all of the available scientific literature related to the toxicology of dioxins and furans in both animal and human studies that was available at that time. Based on their comprehensive review and analysis, the committee concluded that there was a threshold for all toxic effects associated with exposure, including cancer, and that developmental effects represented the most sensitive of all of the toxic endpoint. They concluded that a TDI level based on noncancer effects would also address any potential cancer risk. This conclusion was supported by the subsequent studies conducted by Simon et al. (2009) and NTP (2006).

The committee selected two animal studies to provide the basis for their estimated tolerable monthly intake (TMI). These included the Faqi et al. (1998) study and the Ohsako et al. (2001) study. The Faqi et al. study, which provided the lower of the lowest-observed-effect-level (LOEL), evaluated sensitive, specific endpoints such as male offspring reproductive organ weights, sperm parameters, and testosterone concentrations (JECFA 2001). Liver and testis dioxin concentrations in male offspring, and maternal body burdens, were also evaluated. The Ohsako et al. (2001) study, which provided a no-observed-effect-level (NOEL), related maternal body burdens to sensitive endpoints in male offspring, including testis weight, sperm production, anogenital distance, androgen receptor levels, and adipose and testis TCDD levels. These specific biochemical and functional endpoints, together with use of a body burden dose metric, made the Faqi and Ohsako studies particularly well-suited for evaluation of the effects of TCDD.

Toxicokinetic conversions of these study data to identify equivalent maternal body burdens were conducted using both a linear approach and a power model approach. After converting using a linear model, the committee reported that these two studies indicated a maternal body burden at the LOEL of 25 ng/kg body weight (bw), and a body burden of 13 ng/kg bw

for the NOEL. After conducting the conversion using a power model, the LOEL and NOEL values for these two studies were converted to equivalent maternal body burdens with long-term dosing of 39 and 19 ng/kg bw, respectively.

The committee then evaluated the potential body burdens in the rats resulting from background exposure levels for the animals and concluded that the maternal body burden of TCDD observed in the studies should be adjusted upwards by 3 ng/kg bw to address background concentrations. This adjustment resulted in maternal body burdens of 28 ng/kg bw and 16 ng/kg bw for the LOEL and NOEL, respectively, using the linear model, and maternal body burdens of 42 and 22 ng/kg bw, respectively, using the power model. Using data collected by Hurst et al. (2000a,b), in which maternal and fetal body burdens were compared at Days 15–16 of gestation, these body burdens were estimated to correspond to equivalent human monthly intakes (EHMIs) of 240 and 420 pg/kg bw-month for values derived using the linear model, and EHMIs of 330 and 630 pg/kg bw for value derived using the power model.

JECFA then selected safety factors to adjust those EHMIs. For the Ohsako et al. (2001) study, there was no reason to include factors adjusting from a LOEL to a NOEL, to scale between animals or humans, or to reflect interspecies differences in toxicokinetics or sensitivity. A single default safety factor of 3.2 (square root of 10) was used to adjust the EHMI to reflect interindividual differences among humans. Incorporation of this factor resulted in an estimated range of TMIs, based on the NOEL, of 74 to 103 pg/kg bw-month, depending upon whether the linear or power model was used to estimate the equivalent maternal body burden.

A similar approach was used to adjust the EHMIs based on the Faqi et al. (1998) study. Their default factor of 3.2 was also used to account for interindividual variability. In addition, a second safety factor of 3 was used to adjust for the use of a LOEL instead of a NOEL. This resulted in a total safety factor of 9.6. When this safety factor was applied to the range of EHMIs based on that study (423 to 630 pg/kg bw-month, depending on the use of a linear or power model, respectively), it resulted in a range of TMIs of 44 to 66 pg/kg bw-month.

The committee concluded that the range of provisional tolerable monthly intakes (PTMIs) was 40 to 100 pg/kg bw-month, depending upon the study upon which it was based and the model used to estimate body burden. They selected the mid-point of that range, 70 pg/kg bw-month, to be the PTMI.

JECFA reported this PTMI on a monthly basis to stress its view that there should be no acute RfD for DLCs because of their long half-lives. However, risk assessments conducted in the U.S. generally report exposures as a daily dose, rather than a monthly dose. Thus, the PTMI has been converted to a daily dose level by dividing by an assumption of 30 days per month. This results in a TDI of 2.3 pg/kg-day.

#### 4.1.3.1.7 Discussion

There is a lack of scientific and regulatory consensus concerning the appropriate way to evaluate the carcinogenic potential of TCDD and DLCs. While USEPA and some other regulatory agencies in the U.S. have historically used a linear dose response model to evaluate its potency, there is growing consensus worldwide, including among members of USEPA's SAB and NAS, that there is likely a threshold for TCDD carcinogenicity and that it should be evaluated using a nonlinear, threshold approach (WHO 1998; JECFA 2002; Simon et al. 2009; NAS 2006; ACC 2010). The Texas Commission on Environmental Quality has, on numerous occasions, also supported the use of a nonlinear rather than a linear approach in evaluating the dose response of TCDD (TCEQ 2010a,b, 2011; Haney 2010). In fact, TCEQ (2011) has drafted guidance (currently under review) that asserts that TCDD should be evaluated as a cancer causing chemical that has a threshold dose.

Using the linear approach to dose response modeling, there are many different estimates of TCDD's cancer potency. These differences are due to changes in tumor classification protocols that have occurred since the earlier studies were conducted, alternative approaches for scaling from animals to humans, early mortality corrections, the selected tumor types upon which the dose response models are based, and the choice of the specific linear extrapolation model used to evaluate them. Using the Kociba et al. (1978) data alone, CSF estimates have ranged from 9,700 to 156,000 (mg/kg-day)<sup>-1</sup> (USEPA 1985, 2000; FDA 1993, 1994; Keenan et al. 1991). USEPA's (2010b) proposed CSF, which is based on its analysis of

Seveso epidemiological studies and a linear dose response model, results in a CSF of 1,000,000 (mg/kg-day)<sup>-1</sup>.

CalEPA's CSF of 130,000 (mg/kg-day)<sup>-1</sup> is also questionable because it is based on an older NTP study and was derived using a linearized dose response model. While the newer CalEPA value of 26,000 (mg/kg-day)<sup>-1</sup> is based on newer and better data, it still assumes that there is a linear dose response for TCDD.

The values developed by Simon et al. (2009) for cancer effects reflect current views about the MOA of TCDD and that TCDD likely has a threshold for its carcinogenic activity (TCEQ 2011; De Rosa et al. 1999; SAB 2007, 2011; NAS 2006). The derivation of these values was scientifically transparent and the study was peer reviewed. While Simon et al. (2009) indicated that the RfD of 100 pg/kg-day was probably the more relevant measure of cancer potency, they also presented a value of 100,000 (mg/kg-day)<sup>-1</sup> as a potential CSF based on a linearized approach, in order to address USEPA's historical approach.

JECFA included an international committee of scientific experts. These individuals reviewed all of the available scientific literature related to the toxicology of DLCs that was available at that time and concluded that there was a threshold for all toxic effects associated with exposure, including cancer, and that developmental (noncancer) effects represented the most sensitive of all of the toxic endpoints. They identified a tolerable intake level that addresses both cancer and noncancer effects. Studies that have been conducted since that time have supported their conclusions (e.g., NTP 2006; Simon et al. 2009).

Like Simon et al., JECFA supports the use of a threshold value that can address both cancer and noncancer effects. JECFA concluded that the TDI of 2.3 pg/kg-day was a reliable value from animal studies that can be used for assessing both cancer and noncancer effects of dioxin. Because this value was developed by an expert panel, USEPA (2010b) considers it to be adequately peer reviewed so that it represents a Tier 3 value. This value is well supported by the toxicological literature and an international panel of scientists, so it is consistent with SAB comments on the dioxin reassessment and the opinions of other toxicologists who support the use of a threshold approach in developing toxicological criteria for DLCs (Committee 2006; NRC 2006; Simon et al. 2009; TCEQ 2009, 2010a, 2011). This is the value

that will be used to evaluate the potential carcinogenicity of TCDD and related compounds in the BHHRA.

USEPA has historically used a linear approach for TCDD and has extensively used a CSF of 156,000 (mg/kg-day)<sup>-1</sup> to evaluate its carcinogenic potential. Other scientists have developed linear-based CSFs as low as 9,700 (mg/kg-day)<sup>-1</sup>. In addition, USEPA has more recently proposed a revised, linear-based CSF of 1,000,000 (mg/kg-day)<sup>-1</sup> (USEPA 2003b, 2010b). Thus, depending upon the toxicity value used to evaluate the potential cancer risks associated with dioxin, risk estimates may vary by as much as two orders of magnitude. Because of this, a sensitivity analysis will be presented in the BHHRA to demonstrate the impact of different assumptions about TCDD's carcinogenic potential on the estimates of potential risks.

#### 4.1.3.2 *Noncancer*

USEPA recently published an RfD of 0.7 pg/kg-day for TCDD in its IRIS database, making this a Tier 1 value. As a result, this value will be used to evaluate the potential noncancer effects of TCDD and other DLCs. The basis of this value is discussed in this section.

After an extensive review of the toxicological literature for TCDD, USEPA (2012b) selected two human epidemiological studies to provide the basis for deriving an RfD for the non-cancer effects of TCDD. The studies conducted by Baccarelli et al. (2008) and Mocarelli et al. (2008) provide the data used in developing the recently adopted RfD of 0.7 pg/kg-day. Both of these studies evaluated health effects in human populations that were exposed to dioxins and furans as the result of a trichlorophenol reactor accident that occurred in 1976 in Seveso, Italy (USEPA 2012b).

Baccarelli et al. (2008) reported that there were increased levels of thyroid-stimulating hormone (TSH) measured in newborns that had been exposed to TCDD while *in utero*. The authors of that study used a multivariate regression model that adjusted for variations in gender, birth weight, birth order, maternal age, hospital, and type of delivery, to relate the TCDD concentrations measured in maternal plasma with the TSH level measured in the neonates.

Based on this regression, USEPA defined the LOAEL for this study to be a lipid-adjusted, maternal TCDD serum concentration of 235 parts per trillion (ppt) at the time of delivery, and reported that this corresponded to a neonatal TSH level of 5  $\mu$ U/mL. This neonatal TSH level was selected because it had been selected by WHO as the concentration of TSH to be used as an indicator of potential iodine deficiency and thyroid problems in neonates. USEPA then used physiologically based pharmacokinetic (PBPK) modeling to derive an estimated daily maternal oral intake of 0.020 ng/kg-day as the LOAEL for neonatal TSH levels.

Mocarelli et al. (2008) reported on sperm concentration and motility in men who were between the ages of 1 and 9 years at the time of the accident. Using serum TCDD levels measured within 1 year of the initial exposure, individuals were assigned to one of four quartiles of exposure or a reference group. These authors reported that sperm count was reduced in all four quartiles. In the reference group, which was reported to have a lipid-adjusted serum concentration (LASC) of 15 ppt, the mean sperm concentration was 73 million sperm/mL and the motility was 41 percent. Sperm counts were reduced to 55 million sperm/mL in the lowest exposure group, for which the LASC median was reported to be 68 ppt. In addition, motility was reduced to 36 percent in this group when compared with the reference group. USEPA reported that further decreases in these measures in more highly exposed individuals within the 2nd, 3rd, and 4th quartiles were minimal, with the maximum reduction of 33 percent for sperm concentration in the 4th quartile and 25 percent for sperm motility in the 3rd quartile group. USEPA identified the lowest exposure group (e.g., those in the 1st quartile with a median LASC of 68 ppt) as the LOAEL. They then used PBPK modeling to estimate initial exposure and average exposure over the first 10 years of life, which was identified as the critical window of susceptibility for sperm effects due to TCDD. A LOAEL of 0.020 ng/kg-day was calculated as the average of peak exposure (0.032 ng/kg-day) and average exposure (0.008 ng/kg-day) over the 10-year period.

USEPA then applied uncertainty factors (UFs) to derive its RfD based on the LOAEL of 0.020 ng/kg-day derived from both the Mocarelli et al. (2008) and Baccarelli et al (2008) studies. These UFs were 1) a factor of 10 to adjust from a NOAEL to a LOAEL because a NOAEL could not be identified in either study; 2) a factor of 3 to account for the variable susceptibility within the human population; 3) a factor of 1 for interspecies extrapolation because the RfD was based on human data; 4) a factor of 1 for study duration because it was

reported that developmental effects and other short-term effects occurred at doses similar to effects noted in chronic studies; and 5) a factor of 1 for database deficiencies because of the vast extent of the toxicological database for TCDD and the fact that additional data would not likely affect the magnitude of the RfD. Application of these UFs resulted in a combined UF of 30 that, when applied to the LOAEL of 0.020 ng/kg-day, resulted in an RfD of 0.7 pg/kg-day. This RfD will be used to evaluate the noncancer effects of TCDD.

## **4.2 Polychlorinated Biphenyls**

PCBs are a large family of 209 related congeners. Each of these congeners consists of two benzene rings that are joined by carbon-to-carbon bonds and have variable numbers of chlorine atoms attached in different positions on the rings. These compounds range from mono-chlorinated congeners (having only one chlorine atom) to fully substituted deca-chlorinated congeners (with chlorine at all possible ring locations). Their physical and chemical properties vary substantially depending upon the degree of chlorine substitution and the locations of those substitutions. As a result, solubility and vapor pressures vary greatly among them, affecting their fate, transport, and persistence in the environment.

Most of the PCBs that are found in the environment were released as commercial mixtures that were originally sold in the United States under the trade name of Aroclor. Generally, the Aroclors were identified by trade names such as Aroclor 1254, Aroclor 1248, etc. For most mixtures, the numbering system indicated the degree of chlorination in the mixture as a whole. For example, Aroclor 1254 had 54 percent chlorine content by weight.

Studies of PCBs have indicated they have the potential to cause cancer and other health effects in laboratory animals. As discussed in Section 4.1.1, 12 PCB congeners are assumed to be DLCs. However, the remaining congeners, which may also be present in Site-related media, are not considered to be DLCs.

USEPA's IRIS database provides PCB-specific toxicological criteria but also states that "when congener concentrations are available, the slope-factor approach can be supplemented by analysis of dioxin TEQs to evaluate dioxin-like toxicity. Cancer risks from dioxin-like PCB congeners (evaluated using dioxin TEQs) would be added to risks from the rest of the mixture (evaluated using slope factors applied to total PCBs reduced by the amount of

dioxin-like congeners)” (USEPA 2011a). While IRIS does not discuss the approach to be used for evaluating noncancer effects of dioxin-like PCB congeners, it is presumed that if USEPA adopts its proposed RfD for TCDD, it would recommend the same approach for evaluating the noncancer effects of this subset of PCB congeners. However, USEPA has not yet made any policy statements about the effect that the adoption of the RfD for TCDD will have on PCB risk assessment. Indeed, there is no indication that the endpoints that were selected as the basis for the TCDD RfD are also associated with PCB toxicity, which makes this approach likely to result in substantial uncertainty in estimates of the risks due to PCBs.

As discussed in the response to USEPA’s comments on the draft Soil SAP Addendum 1 (Integral 2011b; Appendix C), the health effects upon which USEPA has derived its toxicological criteria for total PCBs are believed to result from activation of the same AhR-mediated pathways that provide the basis for the “dioxin-like” toxicity of certain PCB congeners. Because the dioxin-like congeners represent a substantial portion of the potential toxicity of the total PCB mixture, application of USEPA’s toxicological criteria for total PCBs to the rest of the mixture (i.e., after subtracting the dioxin-like congeners from the total, as recommended by USEPA), is not scientifically justifiable and will overstate risk for those congeners. Additional uncertainty is introduced by the lack of carcinogenicity data for the remaining PCB congeners.

To address these concerns, two approaches will be used to evaluate the potential cancer risks due to PCBs. First, when PCB congener data are available, total PCB concentrations will be calculated as the sum of the 43 congeners specified by USEPA in its comments on the draft Tissue SAP for the Site (USEPA 2010c) and shown in Table 5.<sup>10</sup> If PCB congener specific data are not available but Aroclor data are, total PCBs will be calculated as the sum of Aroclors. Total PCBs calculated by either method will be evaluated using the CSF that has been specifically developed by USEPA for PCBs (see Section 4.2.1). The estimated cancer risks associated with the total PCB mixture will then be combined with the estimated risks due to other carcinogens to estimate total risks.

<sup>10</sup> It should be noted that there are some additional PCB congeners that are not specified in the list of 43 congeners to be summed but that co-elute with some of the listed congeners. Because the concentrations of the individual components of these co-eluting congener mixtures cannot be determined, these additional congeners will also be included in the sum of total PCBs. The result will be an overestimate of the actual sum of the 43 congeners, as discussed in the Exposure Assessment Memorandum (Integral 2012).

For the second approach, the concentrations of the dioxin-like PCB congeners will be converted to TEQ concentrations ( $TEQ_P$ ), using the appropriate congener-specific TEFs, and the cancer risks from  $TEQ_P$  will be evaluated using the toxicological criteria for TCDD. The resulting risks will then be added to the risks for  $TEQ_{DFP}$  to derive a total risk for  $TEQ_{DFP}$ .

The noncancer hazard analysis will estimate the hazards associated with exposure to total PCBs using the RfD of  $2 \times 10^{-5}$  mg/kg-day recommended in USEPA's IRIS database for highly chlorinated PCB mixtures (see Section 4.2.2). An evaluation of the noncancer PCB hazard with exposures calculated on the basis of  $TEQ_P$  and interpreted using the TCDD RfD will be presented and discussed in the uncertainty analysis.

USEPA has developed both CSFs and RfDs for total PCBs. These criteria are discussed below.

#### **4.2.1 Cancer**

USEPA has classified PCBs as Class B2 carcinogens (probable human carcinogen based on animal studies) and has developed a range of CSFs for them. A 1996 evaluation of the dose response of PCBs (USEPA 1996), which evaluated the results of animal bioassays using different Aroclor mixtures, concluded that exposure of female rats to Aroclors 1260, 1254, 1242, and 1016 resulted in liver tumors. Liver tumors were also observed in male rats exposed to Aroclor 1260. USEPA reported that in evaluating the potential toxicity of these four mixtures of PCB congeners, it was considering all of the PCB congeners that were likely to be found in the environment. It also acknowledged that because of different chemical and physical properties, their fate, transport, and environmental persistence varied (USEPA 1996).

As a result, USEPA (1996) developed a range of CSFs to be used to evaluate PCB mixtures that depended upon the media in which they were present and the degree of chlorination. These CSFs were based on the results of two studies of tumor formation in female rats fed diets containing various PCB mixtures, which were conducted by Brunner et al. (1996) and Norback and Weltman (1985). Tumors considered included hepatocellular adenomas, carcinomas, cholangiomas, or cholangiocarcinomas.

According to IRIS, the cancer potency of PCB mixtures depends on the media of interest, the PCB congeners present, and whether upper bound or central tendency risks are being evaluated. The recommended upper bound CSFs range from 0.07 to 2 (mg/kg-day)<sup>-1</sup>, while the central tendency CSFs range from 0.04 to 1 (mg/kg-day)<sup>-1</sup>.

USEPA's upper bound CSF of 2 (mg/kg-day)<sup>-1</sup> and central tendency CSF of 1 (mg/kg-day)<sup>-1</sup> are to be used for situations where there is a possibility for high risk and persistence. These include food chain exposures, ingestion of soil or sediment, inhalation of dust or aerosols, dermal exposure (if an absorption factor has been applied), presence of dioxin-like, tumor-promoting, or persistent congeners, and early life exposures. According to USEPA, central estimates can be used to describe "a typical individual's risk" and "are useful for estimating aggregate risk across a population," while upper bounds provide assurance that this risk is not likely to be underestimated if the underlying model is correct.

Potential routes of exposure at the Site include the ingestion of fish tissue and direct contact with soils and sediment. Thus, the upper bound CSF of 2 (mg/kg-day)<sup>-1</sup> will be used to evaluate potential carcinogenic risks due to total PCBs.

All of the risk calculations, uncertainties associated with them, and impacts of different assumptions concerning PCBs will be discussed in detail in the risk characterization and uncertainty analysis. In addition, the potential effect of using USEPA's central tendency CSF of 1 (mg/kg-day)<sup>-1</sup> instead of the upper bound CSF will be discussed.

#### **4.2.2 Noncancer**

USEPA's IRIS database includes two different chronic RfDs for PCBs. These include a value of  $2 \times 10^{-5}$  mg/kg-day for Aroclor 1254 and  $7 \times 10^{-5}$  mg/kg-day for Aroclor 1016. Because the congener mixture associated with media at the Site includes many of the more highly chlorinated congeners, the toxicological criterion for Aroclor 1254 will be used to evaluate noncancer hazards due to total PCBs.

The value of  $2 \times 10^{-5}$  mg/kg-day for Aroclor 1254 is based on the results of a study of clinical and immunological effects of Aroclor 1254 in monkeys, conducted by Arnold et al. (1994a,b)

and Tryphonas et al. (1989, 1991a,b). Based on these studies, USEPA derived a LOAEL of 0.005 mg/kg-day as the POD based on ocular exudates, inflamed and prominent Meibomian glands, distorted growth of finger and toe nails, and decreased antibody response to sheep erythrocytes. They then applied a total uncertainty factor of 300 composed of: a factor of 10 to address interindividual sensitivity, a factor of 3 to address interspecies extrapolation, a factor of 3 for the use of a minimal LOAEL as the POD, and a factor of 3 to adjust from subchronic to chronic exposure. This resulted in a chronic, oral RfD of  $2 \times 10^{-5}$  mg/kg-day.

In deriving the chronic RfD for Aroclor 1254, USEPA included a factor of 3 to extrapolate to a chronic RfD based on the subchronic exposure periods used in the studies. Thus, to derive a subchronic RfD for this Aroclor mixture, the factor of 3 was removed. This resulted in a subchronic RfD of  $6 \times 10^{-5}$  mg/kg-day for Aroclor 1254. This will be used to evaluate subchronic hazards due to total PCBs.

As for the estimation of cancer risks, two different approaches will be used to evaluate the potential noncancer effects of PCBs in the media of concern. The first analysis will evaluate noncancer hazards by estimating exposures using the sum of the 43 congeners, when congener data are available, or as the sum of Aroclors when Aroclor data are available, and interpreting results to estimate noncancer hazards using the Tier 1, PCB-specific RfD of  $2 \times 10^{-5}$  mg/kg-day.

In a second analysis, the concentration TEQ<sub>P</sub> will be estimated using the TEF approach. The resulting exposures to TEQ<sub>P</sub> will then be compared with the RfD for TCDD to derive the estimated hazard associated with the dioxin-like congeners.

### **4.3 Bis(2-ethylhexyl)phthalate**

USEPA's IRIS database provides both noncancer and carcinogenic toxicological criteria for bis(2-ethylhexyl)phthalate (BEHP), identified as di(2-ethylhexyl)phthalate. These values, and the studies upon which they are based, are discussed below.

#### **4.3.1 Cancer**

BEHP is classified as a B2 carcinogen (probable human carcinogen). This classification is based on a dose-related increase in liver tumors observed in male and female rats and mice that received BEHP via a dietary study (NTP 1982b). The available human carcinogenicity

data were deemed inadequate for evidence of a causal relationship. USEPA's CSF for BEHP is  $0.014 \text{ (mg/kg/day)}^{-1}$ .

The animal carcinogenicity data from the NTP (1982b) study were deemed sufficient evidence of a causal relationship. In that study, groups of male and female rats were fed diets containing BEHP at concentrations of 0, 6,000, or 12,000 ppm for 103 weeks. In addition, male and female mice were fed diets containing BEHP at concentrations 0, 3,000, or 6,000 ppm for 103 weeks. No clinical signs of toxicity were observed. However, significant increases in hepatocellular carcinomas and combined incidences of carcinomas and adenomas were observed in female rats and mice of both sexes. Male rats receiving the highest dose showed a significant increase in combined incidence of neoplastic nodules and hepatocellular carcinomas. A positive dose response trend was noted.

#### **4.3.2 Noncancer**

USEPA has published a chronic oral RfD of 0.02 mg/kg-day for BEHP in its IRIS database. That RfD is derived from the Carpenter et al. (1953) study of chronic oral toxicity in rats and guinea pigs.

In that study, groups of male and female guinea pigs were fed diets containing 0.04 or 0.13 percent BEHP for a period of 1 year. A control group was also used. No treatment-related side effects were observed with the exception of a statistically significant increase in relative liver weights in both groups of treated females.

In addition, male and female groups of Sherman rats were fed a diet containing 0.04, 0.13, or 0.4 percent BEHP in a 2-year reproductive study. At the 0.4 percent dietary level, the parental and F1 rats showed retarded growth and increased kidney and liver weights. The F1 treated and control groups showed high levels of mortality: 46.2 and 42.7 percent, respectively.

Based on the results of this study, a LOAEL of 19 mg/kg-day was identified. This was adjusted by a factor of 1,000, which consisted of three individual uncertainty factors of 10. The first two factors were used to account for interspecies variation and protection of human subpopulations, respectively; the third combined factor of 10 (assumed to be two factors,

each of 3.2 or the square root of 10) was used because the exposure period for the guinea pig represented greater than subchronic but less than lifetime exposure and the RfD was based on a LOAEL rather than a NOAEL, although the observed affect was reported to be minimally adverse. This resulted in a chronic RfD of 0.02 mg/kg-day.

USEPA's IRIS database has no listing for subchronic oral exposure to BEHP. However, as an uncertainty factor of the square root of 10 (3.2) was used to derive the chronic RfD, because the duration of the study upon which it was based was less than lifetime but greater than subchronic, removing this factor provides a conservative subchronic oral RfD of 0.6 mg/kg-day.

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## 5 TOXICOLOGICAL CRITERIA FOR METALS

This section presents the toxicological criteria that will be used to evaluate the toxicity of metal COPCHS at the Site. The criteria to be used to evaluate potential risks and hazards associated with metals are provided in Tables 2 and 3.

### 5.1 Arsenic

Arsenic that occurs in soil is generally in an inorganic form and consists of a mixture of chemical compounds with differing particle sizes and morphologies. It may be present in differing valence states and may include co-precipitated and sorbed species that are associated with other minerals and/or organic matter. USEPA's IRIS database provides both a CSF and an RfD for inorganic arsenic. In addition, USEPA has proposed but not yet adopted, a newly revised CSF for this compound.

The majority of arsenic that is present in food products, particularly fish, is organic arsenic (ATSDR 2007; TDSHS 2008). No Tier 1 or Tier 2 toxicological criteria are available for organic arsenic. However there is substantial evidence that organoarsenicals are substantially less toxic than the inorganic forms of arsenic upon which the USEPA toxicological criteria are based. Information provided in toxicological literature about the relative toxicity of organoarsenicals indicates that they are likely to be orders of magnitude less toxic than inorganic species.

This section includes a discussion of the toxicity of inorganic arsenic, which is the form that is likely to be found in soil, sediment, and water. Because USEPA has proposed, but has not yet adopted, an alternative CSF for inorganic arsenic, this proposed value and the implications of its adoption are discussed. Finally, this section presents a discussion of the relative toxicity of organic forms of arsenic, compared with inorganic forms, and the manner in which organoarsenicals will be evaluated in the risk assessment.

#### 5.1.1 Inorganic Arsenicals

USEPA has developed both a CSF and an RfD for inorganic arsenic and they are available in the IRIS database. These represent Tier 1 values for arsenic.

#### 5.1.1.1 Carcinogenic Potential

USEPA has classified inorganic arsenic as a Class A carcinogen (human carcinogen) in its IRIS database. This classification is based on evidence from human epidemiological data, which indicated increased lung cancer mortality in multiple human populations that were exposed via inhalation. They also reported increased mortality from liver, kidney, lung, and bladder cancer, and an increased incidence of skin cancer in human populations that consumed drinking water containing high concentrations of inorganic arsenic.

USEPA developed the CSF for arsenic based on the studies conducted by Tseng et al. (1968) and Tseng (1977). These authors studied roughly 40,000 Taiwanese individuals who were exposed to arsenic in their drinking water and compared the results with 7,500 unexposed individuals. Three dose intervals and four exposure durations were considered separately for males and females. The prevalence of skin cancer was considered the endpoint of interest and a multistage model was used for the dose response assessment. Estimated intake rates for the Taiwanese population was adjusted to reflect differences between the Taiwanese and U.S. populations, in terms of daily water intake and body weight. The authors conducted both linear and quadratic model fitting of the data and estimated that the maximum likelihood estimate of skin cancer risk for a 70 kg adult who consumed 2 L of water per day, which ranged from 0.001 to 0.002, was associated with an arsenic intake of 1  $\mu\text{g/kg-day}$ . Based on this, they derived a cancer unit risk for drinking water of  $5 \times 10^{-5} (\mu\text{g/L})^{-1}$  and an oral CSF of  $1.5 (\text{mg/kg-day})^{-1}$ .

USEPA has been working on a reevaluation of the carcinogenicity of inorganic arsenic since 2003 and issued its first draft toxicological review in July 2005, in which it proposed an oral CSF of  $5.7 (\text{mg/kg-day})^{-1}$ . Subsequently, they released a 2008 draft review in which a value of  $30.5 (\text{mg/kg-day})^{-1}$  was presented for interagency review. In March 2009, another draft was released in which a value of  $25.7 (\text{mg/kg-day})^{-1}$  was proposed for interagency review. The final draft, which was released for public review and comments in February 2010, retained the proposed 2009 CSF of  $25.7 (\text{mg/kg-day})^{-1}$ . This value represents a 17.1-fold increase in the calculated CSF (i.e., a 17.1-fold increase in estimated toxicity).

This proposed CSF is based on combined lung and bladder cancer in Taiwanese women exposed via drinking water, as reported in epidemiological studies by Chen et al. (1988, 1992)

and Wu et al. (1989), rather than the skin cancer endpoint upon which the original CSF was based. The development of the CSF consisted of several steps. First, a dose-response model for the Taiwanese population was fitted. The dose-response model selected was a Poisson regression with linear dose terms and quadratic age terms. Second, the arsenic cancer risk in a hypothetical U.S. population was estimated at varying arsenic concentrations in drinking water. Cancer incidence risks for the U.S. population were calculated for each 5-year stratum and then summed to give an estimate of lifetime cancer incidence. The dose was then adjusted until the estimated extra incidence risk from arsenic equaled 1 percent for the U.S. reference population. The dose that fulfilled this condition was used to derive the lowest effective dose, which was the lower confidence limit on the dose corresponding to a 1 percent lifetime incidence risk in the U.S. population. Finally, a linear extrapolation from this POD was applied.

Separate CSFs were calculated for males, females, and combined males/females for each of the two endpoints. These CSFs ranged from 6.7 to 25.7 (mg/kg-day)<sup>-1</sup>, with the highest value based on combined lung and bladder cancer incidence in females. The combined CSF for females was selected as the POD because it represented the most sensitive endpoint. It should be noted that the sensitivity analysis conducted by USEPA found that female bladder cancer incidence was highly sensitive to non-water (dietary) arsenic intake; a value that was assumed to be equal between the Taiwanese (reference) and U.S. (target) populations. Data for actual non-water arsenic intakes in the Taiwanese population in the epidemiological studies used were not collected.

The data upon which this revised value is based and the approach used to develop it have a number of deficiencies or simplifying assumptions that make this estimate highly uncertain. Many of these deficiencies and assumptions are similarly limitations of the current CSF. These include the following:

- The arsenic exposure was “ecological” (based upon concentrations measured in village wells). There was no measure of individual arsenic exposure. In addition, measured arsenic concentrations in well water were variable (ranging up to an order of magnitude, depending upon the study). Also, the analytical method used for detection of arsenic in well water in all of the Taiwanese studies was less sensitive

than current analytical methods, with detection limits of approximately 10 µg/L (the current MCL).

- There was no consideration of the potential confounding effects of smoking within the exposed population. Later evaluations suggested that the percentage of smokers across the target and reference populations was the same; however, this is a substantial source of uncertainty because lung cancer mortality is one of the two major endpoints considered in developing the proposed value.
- There was no information on non-water (dietary) arsenic intake. This is a considerable limitation because the rural Taiwanese population consumes a rice-based diet that is relatively high in inorganic arsenic concentration, whereas the U.S. population does not.
- While USEPA included a summary and data quality evaluation of many high-dose and low-dose epidemiological studies, these studies were not considered quantitatively in the development of the revised CSF.
- There is considerable evidence that a threshold dose must be reached before arsenic exposure results in a carcinogenic response (Schoen et al. 2004; Snow et al. 2005). Thus, the use of a linear dose response model that USEPA used may not be appropriate.
- Several key events have been identified in arsenic carcinogenesis and it has been postulated that there are multiple pathways to human carcinogenesis from inorganic arsenic exposure (as many as nine different pathways have been postulated). USEPA agreed that the metabolic pathways and MOA may differ for low-dose versus high-dose exposures. In general, animal bioassay data from several species have been negative for cancer. This was hypothesized to be due to greater methylation rates (e.g., detoxification via metabolism) in animals compared to humans.
- Human epidemiological data at high doses support the classification of arsenic as a human carcinogen. However, as noted by SAB (2007), human epidemiological data at low doses, in general, do not support the classification of arsenic as a human carcinogen.

This proposed CSF is still a draft value that has not been formally adopted by USEPA. Its date for completion is to be determined. Thus, the current oral CSF of  $1.5 \text{ (mg/kg-day)}^{-1}$  will be used to evaluate the potential carcinogenic effects of inorganic arsenic.

#### **5.1.1.2 Reference Dose**

USEPA has developed a chronic RfD for inorganic arsenic of  $3 \times 10^{-4}$  mg/kg-day. This is based on hyperpigmentation, keratosis, and possible vascular complications observed in the study of human chronic oral exposure conducted by Tseng (1977) and Tseng et al. (1968). These are the same studies discussed previously in the discussion of the current CSF for inorganic arsenic published in USEPA's IRIS database.

Based on the data from this study, USEPA identified a NOAEL of  $8 \times 10^{-4}$  mg/kg-day as the POD. They then applied an uncertainty factor of 3 to account for some uncertainty in whether the NOAEL accounts for all sensitive individuals and to address the lack of data to preclude reproductive toxicity as a critical effect. This resulted in a chronic oral RfD of  $3 \times 10^{-4}$  mg/kg-day.

USEPA has not developed a subchronic RfD for inorganic arsenic and no subchronic toxicity criterion was identified in the Tier 3 sources evaluated. In addition, in deriving the chronic RfD, USEPA incorporated no uncertainty factor to adjust from subchronic to chronic exposures. Thus, the chronic RfD of  $3 \times 10^{-4}$  mg/kg-day will be used to evaluate both chronic and subchronic exposures to arsenic, as appropriate.

#### **5.1.2 Organic Arsenicals**

There are a variety of organic arsenic species to which humans are exposed from their diet. These include monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), arsenobetaine, and arsenocholine, along with other less common species.

USEPA does not provide toxicological criteria (i.e., CSFs or RfDs) in its IRIS database or PPRTVs for the evaluation of organoarsenicals. ATSDR (2007) has, however, developed toxicological criteria for two organic arsenicals.

The toxicity of organic arsenic is very low compared to the toxicity of inorganic species. According to Lawrence et al. (1986), elevated levels of arsenobetaine or arsenocholine, which are commonly found in fish tissue, do not pose a human health hazard. Similarly, Dabeka et

al. (1993) reported that while arsenic levels are generally elevated in fish tissue, most of the arsenic in those tissues is arsenobetaine, which is generally excreted unaltered from humans and is considered to be relatively nontoxic. Ng et al. (1998) also reported that exposure to organic arsenic is generally not considered to result in substantial health risks.

In its *Toxicological Profile for Arsenic* (ATSDR 2007), ATSDR has developed chronic MRLs for both MMA and DMA. ATSDR has also developed an intermediate (subchronic) MRL for MMA. Each of these values is discussed below.

ATSDR's chronic MRL for MMA is based on a study conducted by Gur et al. (1991) in which male and female B6C2F<sub>1</sub> mice were exposed to MMA in their diets at concentrations of 10, 50, 200, or 400 mg/kg for a period of 104 weeks. The dose levels were reported to be 1.2, 6.0, 24.9, or 67.1 mg MMA/kg-day for the males, and 1.4, 7.0, 31.2, or 101 mg MMA/kg-day for the females. No treatment-related increases in mortality were noted but there were significant decreases in body weights in males exposed to 32.2 mg/kg-day and females exposed to 48.5 mg/kg-day.<sup>11</sup> Food consumption was increased at the high dose levels and loose and mucoid feces were also noted. There was an increased incidence of progressive glomerulonephropathy in males at all of the dose levels and the incidence was significantly higher than controls at dose levels of 6 mg/kg-day and above.

ATSDR conducted a benchmark dose analysis for progressive glomerulonephropathy in the male mice. Predicted doses associated with an increased risk of 10 percent (BMDL<sub>10</sub>) were calculated. The BMDL<sub>10</sub> of 1.09 mg/kg-day was used as the POD. A total uncertainty factor of 100 was applied, reflecting a factor of 10 for extrapolation from animal to humans and a factor of 10 for human variability. This resulted in a chronic MRL of 0.01 mg/kg-day.

While ATSDR also calculated a chronic MRL for DMA based on a study conducted by Gur et al. (1989), this calculated MRL of 0.02 mg/kg-day was higher than the MRL calculated for MMA. Thus, the chronic MRL of 0.01 mg/kg-day calculated for MMA will be used to estimate potential chronic risks associated with organoarsenicals.

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<sup>11</sup> There is a discrepancy in the worksheet on the MRL for MMA. Dose levels of 32.2 and 48.5 mg/kg-day are not reported to be dose levels in the Gur et al. study but are the dose levels at which decreased body weights were reported to be significant. The reason for the discrepancy is unclear.

ATSDR's intermediate MRL for MMA is based on a study conducted by Crown et al. (1990) in which male and female Fischer 344 rats received dietary levels of MMA ranging from 50 to 1,300 ppm for a period of 104 weeks. Dose levels ranged from 3.5 to 106.9 mg/kg-day for the males and 4.2 to 123.3 mg/kg-day for the females. Mortality increased in the high dose groups during the first 52 weeks; body weights decreased and food and water consumption increased in both the mid- and high-dose levels of both sexes. Diarrhea occurred in both the high- and mid-dose groups and its severity was dose-related. The gastrointestinal system was the target organ in the animals that died early and numerous macroscopic and histological alterations were observed.

ATSDR conducted a benchmark dose analysis of the dose-response data for diarrhea in male and female rats. Predicted doses associated with a 10% extra risk (BMDL<sub>10</sub>) were calculated. The lowest predicted BMDL<sub>10</sub> of 12.38 mg/kg-day for the female rats was selected as the POD for deriving an intermediate oral MRL. Two uncertainty factors were incorporated: a factor of 10 for extrapolation from animals to humans, and a factor of 10 for variability within the human population. This resulted in an intermediate MRL of 0.1 mg/kg-day. This intermediate MRL will be used to evaluate subchronic exposures to organic forms of arsenic.

### 5.1.3 Discussion

The IRIS RfD of  $3 \times 10^{-4}$  mg/kg-day and CSF of  $1.5 \text{ (mg/kg-day)}^{-1}$  for inorganic arsenic represent Tier 1 toxicological criteria. Thus, these values will be used in addressing the potential chronic health effects of inorganic arsenic in all media. The chronic RfD ( $3 \times 10^{-4}$  mg/kg-day) will also be used to evaluate the potential subchronic exposures to inorganic arsenic.

For the fish ingestion pathway, for which exposure is likely to be substantially associated with intake of organic arsenic, the percent of inorganic arsenic will be estimated as 10 percent of the total arsenic concentration in tissue and will be evaluated using the toxicological criteria for inorganic arsenic. The chronic and intermediate MRLs of 0.01 and 0.1 mg/kg-day for MMA, respectively, which were developed by ATSDR (2007) will be used to evaluate potential chronic and subchronic risks associated with the organic arsenic in fish tissues (90 percent of total arsenic concentration in tissue).

In addition, USEPA has proposed a higher CSF for inorganic arsenic than the current Tier 1 value. If this value is formally adopted, the resulting risks will be higher by roughly a factor of 17. Thus, this issue will also be addressed in the discussion of uncertainties concerning arsenic risks.

## **5.2 Cadmium**

USEPA's IRIS database does not provide a CSF for cadmium. It does, however, provide oral noncancer RfDs cadmium. These values, and the basis for each, are discussed below.

### **5.2.1 Cancer**

USEPA has classified cadmium as a Class B1 carcinogen (probable human carcinogen) based on studies of animals exposed by inhalation and intramuscular and subcutaneous injection, but has not classified it for oral exposure. However, information on carcinogenic risk from oral exposure is not available in USEPA's IRIS database as there are no positive studies of orally ingested cadmium deemed suitable for quantitation. Because there is no oral CSF available for cadmium, its potential carcinogenicity cannot be quantified. The uncertainties associated with its omission from total cancer risks will be discussed in the uncertainty analysis.

### **5.2.2 Noncancer**

USEPA has published chronic oral RfDs for cadmium of  $5 \times 10^{-4}$  mg/kg-day and  $1 \times 10^{-3}$  mg/kg-day for exposures via water and food, respectively, in its IRIS database. Because the water ingestion pathway has not been identified as a significant pathway for the BHHRA, the food-based RfD of  $1 \times 10^{-3}$  mg/kg-day will be used in this assessment.

Based on its review of a number of studies, USEPA identified a concentration of 200 µg Cd/g wet human renal cortex as the highest renal concentration that was not associated with significant proteinuria. A toxicokinetic model was then used to identify the dose level that would result in a concentration of 200 µg Cd/g wet human renal cortex, assuming that 0.01 percent of the cadmium body burden is eliminated per day. The toxicokinetic model predicted NOAEL concentrations of 0.005 and 0.01 mg Cd/kg-day for water and food,

respectively. An uncertainty factor of 10 was used to account for intra-human variation in the absence of specific data on sensitive individuals.

USEPA does not provide a subchronic RfD for cadmium and no uncertainty factor was incorporated in the derivation of the chronic RfD to adjust for study duration. While ATSDR (2008a) has developed an intermediate MRL for cadmium based on drinking water exposures for mice, this value is identical to the chronic RfD developed by USEPA. Thus, USEPA's chronic value of  $1 \times 10^{-3}$  mg/kg-day for the food pathway will be used to evaluate both chronic and subchronic exposures.

### **5.3 Chromium**

The data that are available for chromium are reported as total chromium and are not speciated by valence state. USEPA's 2011 IRIS database discusses the toxicity of both trivalent and hexavalent chromium (chromium(III) and chromium(VI), respectively). It provides no CSF values for either valence state, as discussed in Section 5.3.1 below. It does, however, provide noncancer toxicological criteria for both chromium(III) and chromium(VI). These values, and the studies upon which they are based, are discussed below. Section 5.3.3 discusses the way in which these toxicological criteria will be applied to the existing data for the BHHRA.

#### **5.3.1 Cancer**

##### **5.3.1.1 Chromium(III)**

Chromium(III) is classified as a Class D carcinogen (not classifiable as to human carcinogenicity). USEPA has determined that there are inadequate data to determine the potential carcinogenicity of chromium(III) and, thus, has not developed a CSF for it.

##### **5.3.1.2 Chromium(VI)**

Chromium(VI) is listed as a Class A carcinogen (human carcinogen) for the inhalation pathway. It is not classifiable, however, as a carcinogen via the oral route as USEPA found no data suggesting oral carcinogenicity and so USEPA has classified it as a Class D carcinogen (not classifiable) for the oral pathway. Thus, no oral CSF has been developed.

### **5.3.2 Noncancer**

#### **5.3.2.1 Chromium(III)**

USEPA has published a chronic oral RfD of 1.5 mg/kg-day for chromium(III) in its IRIS database. The RfD is derived from a study by Ivankovic and Preussman (1975), who reported an absence of toxic and carcinogenic effects at high doses of chromic oxide pigment in subacute and long-term feeding experiments. Groups of male and female rats were fed chromic oxide baked into bread at dietary levels of 0, 1, 2, or 5 percent, 5 days per week for 840 days. The primary purpose of the study was to assess the carcinogenic potential of the chromic oxide. Animals were maintained on control diets after the treatment until they became moribund or died. There were no effects observed at any treatment level. In addition, they treated rats of both sexes at dietary levels of 0, 2, or 5 percent chromic oxide in bread for 5 days per week for 90 days. They observed a 12–37 percent reduction in the absolute weights of the livers and spleens in the high dose group.

The high dose was equivalent to an oral dose of 1,400 mg/kg-day. A total uncertainty factor of 100 was used. This uncertainty factor comprised a factor of 10 to account for expected interhuman and interspecies variability and an additional modifying factor of 10 to reflect database deficiencies including a lack of a non-rodent study animal, lack of unequivocal data on reproductive impacts, and a concern regarding potential reproductive effects. Additional uncertainties that influenced the modifying factor relating to the NOAEL value from Ivankovic and Preussman (1975) included effects observed in the 90-day study that were not addressed in the 2-year study, an uncertain effect of the baked bread on absorption of chromic oxide, and the fact that the animals were not sacrificed at the end of the study but were instead allowed to die naturally.

No subchronic RfD for oral exposures to chromium(III) has been developed by either USEPA or ATSDR (2008b). In addition, no uncertainty factor was incorporated in USEPA's derivation of the chronic RfD to adjust for study duration. Thus, the chronic RfD of 1.5 mg/kg-day will be used to evaluate both chronic and subchronic exposures, as appropriate.

### 5.3.2.2 Chromium(VI)

USEPA has published an oral RfD of  $3 \times 10^{-3}$  mg/kg-day for chromium(VI) in its IRIS database. The RfD is derived from a study by MacKenzie et al. (1958) in which hexavalent chromium was administered to rats via drinking water. Groups of male and female rats were given drinking water containing between 0.45 and 11.2 ppm hexavalent chromium (as  $K_2CrO_4$ ) for 1 year. The control group received distilled water. An additional experiment was conducted in which one group of rats received 25 ppm  $K_2CrO_4$  in water, one group received 25 ppm chromic chloride in water, and one group received distilled water. No adverse effects were seen in any treatment group in either experiment. Rats receiving 25 ppm  $K_2CrO_4$  in water showed a 20 percent decrease in water consumption. In addition, an abrupt rise in tissue chromium concentrations occurred in rats treated with >5 ppm.

A NOAEL of 2.5 mg/kg-day was calculated based on these data. A total uncertainty factor of 300 was applied. It included two factors of 10 to account for interhuman and interspecies variability, respectively, and an additional factor of 3 to adjust for less than lifetime exposure. In addition, a modifying factor of 3 accounted for concerns raised in a study by Zhang and Li (1987), in which human subjects exposed to chromium concentrations of approximately 20 mg/L displayed gastrointestinal effects. This resulted in a total adjustment factor of 900.

USEPA's IRIS database has no listing for subchronic oral exposure of chromium(VI). However, in deriving its chronic RfD, USEPA incorporated an uncertainty factor of 3 to adjust for less than lifetime exposure in the animal study. Removing this factor results in a subchronic oral RfD of  $8 \times 10^{-3}$  mg/kg-day.

### 5.3.3 Application of Toxicological Criteria for Chromium

The available data for chromium are reported on the basis of total chromium and are not speciated. It is likely that most of the chromium that is present in the media of concern is chromium(III) but it is also acknowledged that some percentage of the chromium may be in the hexavalent state. Thus, for the BHHRA, the initial risks associated with exposure to chromium will be evaluated using the toxicological criteria for chromium(III). A sensitivity analysis will then be incorporated into the uncertainty analysis to demonstrate the risks that would be derived if it were assumed that all of the

chromium is hexavalent or that the chromium is a combination of trivalent and hexavalent forms.

## **5.4 Copper**

USEPA's 2011 IRIS database provides no toxicological criteria (CSF or RfDs) for copper. However, USEPA published a chronic oral RfD for copper in its 1997 HEAST (USEPA 1997), and ATSDR (2004) has calculated an intermediate MRL for copper. Both of these values are discussed below.

### **5.4.1 Cancer**

USEPA lists copper as a Class D carcinogen (not classified) based upon inadequate animal studies and a complete lack of human studies. It has developed no CSF for copper.

### **5.4.2 Noncancer**

The chronic oral RfD published by USEPA in its HEAST (USEPA 1997) is 1.3 mg/L and is based on USEPA's Drinking Water Criteria Document for Copper (USEPA 1987c). Assuming a drinking water ingestion rate of 2 L/day and a body weight of 70 kg, as outlined in USEPA's *1997 Exposure Factors Handbook*, results in a chronic oral RfD of 0.04 mg/kg-day, which is the value used by USEPA in developing its regional soil screening concentrations (USEPA 2011b). This value will be used to evaluate chronic exposures to copper.

ATSDR (2004) has developed an intermediate MRL of 0.01 mg/kg-day for copper based on an epidemiological study conducted by Araya et al. (2003). In that study, men and women were exposed to copper in drinking water containing concentrations of 2, 4, or 6 mg/L for 2 months. Dose levels were not measured but were estimated, using a body weight of 65 kg, to range from 0.042 to 0.17 mg/kg-day. Gastrointestinal symptoms were noted in all dose groups. However, ATSDR based its MRL on an assumed NOAEL of 0.042 mg/kg-day and then incorporated an uncertainty factor of 3 to address human variability. This resulted in an intermediate oral MRL of 0.01 mg/kg-day.

This intermediate MRL is highly uncertain for a number of reasons. Dose levels were estimated using a single assumed body weight for males/females combined, rather than measured. It is not clear whether individual drinking water intakes were measured for each individual, and there is little information provided about potential confounding factors. In addition, while gastrointestinal disturbances were noted at all dose levels, ATSDR selected the mid-dose level as a NOAEL without explanation. Finally, the toxicological significance of gastrointestinal disturbances is not clear. Because of these uncertainties, the chronic RfD of 0.04 mg/kg-day developed by USEPA will be used instead to evaluate both chronic and subchronic exposures to copper.

## **5.5 Mercury**

Mercury salts, like mercuric chloride, are most often found in abiotic media, such as soil and sediment, while the mercury in fish tissue is generally methylmercury. USEPA has developed toxicological criteria for both mercuric forms of mercury and methylmercury as presented in IRIS.

### **5.5.1 Mercuric Chloride**

USEPA's IRIS database includes information regarding the carcinogenicity of mercuric chloride, but does not provide a quantitative estimate with which to evaluate potential cancer risks. The IRIS database does include an oral RfD for this compound. Toxicological criteria for mercuric chloride will be used to evaluate direct contact with soils and sediment at the Site.

#### **5.5.1.1 Cancer**

USEPA's IRIS has classified mercuric chloride as a Class C carcinogen (possible human carcinogen) based on an absence of human data and limited evidence of carcinogenicity in animals. It has not developed a CSF for this compound.

#### **5.5.1.2 Noncancer**

The RfD for mercuric chloride presented in IRIS is not based on a single study but is instead based on the WOE from three studies of toxicity in Brown Norway rats and the available

database on mercuric mercury. In 1987, USEPA convened a Peer Review Workshop to resolve a number of issues related to mercury toxicity. This panel of mercury experts concluded that the most sensitive adverse effect for mercuric forms of mercury is the formation of mercuric-mercury-induced autoimmune glomerulonephritis and that the Brown Norway rat is a good test species for this endpoint. Thus, the panel chose three studies that used the Brown Norway rat as the basis for their recommended Drinking Water Exposure Level (DWEL) of 0.010 mg/L for inorganic mercury. They then back-calculated from that value, using a water ingestion rate of 2 L/day and a body weight of 70 kg, to derive the oral RfD of  $3 \times 10^{-4}$  mg/kg-day presented in IRIS.

Three studies using the Brown Norway rat as the test strain were chosen as the basis for the panel's recommendation of 0.010 mg/L as the DWEL for inorganic mercury (Druet et al. 1978; Bernaudin et al. 1981; Andres 1984). Each of these studies is discussed below.

In the Druet et al. (1978) study, male and female Brown Norway rats were divided into groups of 6–20 animals each. The animals received mercuric chloride subcutaneously, three times a week for a period of 8 weeks. Doses ranged from 100 to 2,000  $\mu\text{g/kg}$ . An additional group was injected at a lower dose of 50  $\mu\text{g/kg}$  for a period of 12 weeks. Tubular lesions were observed at the higher dose levels and proteinuria, which was considered highly deleterious because the affected animals developed hypoalbuminemia and many died, was reported at doses of 100  $\mu\text{g/kg}$  or greater. Fixation of IgG antiserum was detected in all groups except controls (Druet et al. 1978).

Bernaudin et al. (1981) reported that male and female Brown Norway rats that were exposed to mercurials via inhalation or ingestion developed a systemic autoimmune disease. Those that ingested the mercurials were force fed either 0 or 3,000  $\mu\text{g/kg}$  per week for up to 60 days. While no abnormalities were reported using standard histological techniques in either set of rats, immunofluorescence histology revealed that 80 percent of the exposed rats had a linear IgG deposition in the glomeruli after 15 days of exposure. After 60 days of exposure, 100 percent of the exposed rats had a mixed linear and granular pattern of IgG deposition in the glomeruli, and granular IgG deposition in the arteries. Weak proteinuria was observed in 60 percent of the exposed rats. The control rats had no deposition of IgG in the glomeruli or arteries, and also had normal levels of protein in their urine.

Andres (1984) gavaged five Brown Norway rats and two Lewis rats at dose rates of 3 mg/kg of mercuric chloride in 1 mL of water, two times per week for 60 days. A sixth Brown Norway control rat was given 1 mL of water by gavage at the same rate. After 2 to 3 weeks of exposure, the treated Brown Norway rats started to lose weight and hair; two of them died 30 to 40 days after the start of the study. No rats developed proteinuria during the study period. While standard histological techniques indicated that the kidneys were normal in all animals, examination by immunofluorescence showed deposits of IgG present in the renal glomeruli of only the treated Brown Norway rats. These rats also had mercury-induced morphological lesions of the ileum and colon, abnormal deposits of IgA in the basement membranes of the intestinal glands, and abnormal deposits of IgG in the basement membranes of the *lomina propria*. These same effects were not seen in either the Lewis rats or the control Brown Norway rat.

Based on the WOE from these studies, USEPA selected a LOAEL of 0.317 mg/kg-day. They then applied a total uncertainty factor of 1,000. This included factors to adjust for the use of a LOAEL instead of a NOAEL, use of a subchronic study to develop a chronic RfD, and a combined factor of 10 to account for animal to human extrapolation and differing sensitivity within the human population. This resulted in a chronic oral RfD of  $3 \times 10^{-4}$  mg/kg-day.

To derive the chronic RfD based on a subchronic study, an uncertainty factor of 10 was applied. Removing this factor results in a subchronic RfD of  $3 \times 10^{-3}$  mg/kg-day.

### **5.5.2 Methylmercury**

USEPA has not developed a CSF for methylmercury. It does, however, provide a noncancer toxicity criterion for it.

While total mercury concentrations have been measured in fish tissue, methylmercury is the form of mercury that is most commonly found in fish tissue. Thus, the toxicological criteria for methylmercury will be used to evaluate potential risks due to ingestion of mercury in fish tissue.

#### 5.5.2.1 Cancer

USEPA lists methylmercury as a Class C carcinogen (possible human carcinogen) based on inadequate data in humans and limited evidence of carcinogenicity in animals. It provides no CSF for it.

#### 5.5.2.2 Noncancer

USEPA has established a chronic oral RfD of  $1 \times 10^{-4}$  mg/kg-day in its IRIS database. This value is based on results from three epidemiological studies conducted in the Seychelles, the Faroe Islands, and New Zealand. The Seychelles study reported by Myers et al. (1995a,b,c, 1997) and Davidson et al. (1995, 1998) was a longitudinal study of 779 mother–infant pairs from a fish-eating population. Children were followed from birth to 5.5 years of age, and evaluated at various ages for a number of standardized neuropsychological endpoints. They used maternal-hair mercury levels as the independent variable. The study in the Faroe Islands conducted by Grandjean et al. (1997) assessed 900 mother–infant pairs using primarily cord-blood mercury levels (maternal hair levels were also taken). At 7 years of age, children were assessed using a number of tasks designed to evaluate various behavioral patterns. A study conducted in New Zealand by Kjellstrom et al. (1989, 1986) was also taken into consideration by USEPA. In the New Zealand study, 38 children of mothers with hair mercury levels >6 ppm were matched with children whose mothers had lower hair mercury levels. At age 6, 237 children were then assessed for a number of neuropsychological endpoints similar to the Seychelles study. They found no evidence of impairment due to *in utero* methylmercury exposure, whereas the Faroe Island and Seychelles studies found a dose-related response. The Faroe Island study is the primary study that USEPA chose to use to derive its oral RfD for methylmercury, with supporting evidence from the New Zealand study. USEPA used the K power benchmark dose model developed by Budtz-Jørgensen et al. (1999, 2000) to derive an oral RfD from the Faroe Island study. An uncertainty factor of 10 was applied to account for variability and uncertainty in pharmacokinetics and pharmacodynamics.

USEPA has not provided a subchronic toxicity value for methylmercury. In addition, no uncertainty factor was incorporated in the derivation of USEPA's chronic RfD to adjust for study duration, and ATSDR (1999) has not developed an intermediate MRL for

methylmercury. Thus, the chronic RfD of  $1 \times 10^{-4}$  mg/kg-day will be used to evaluate both chronic and subchronic exposures, as appropriate.

## 5.6 Nickel

USEPA's 2011 IRIS database has not evaluated nickel as a carcinogen and does not provide a CSF. The database does provide an oral noncancer RfD for nickel. This value, and its basis, is discussed below.

### 5.6.1 Cancer

While USEPA has evaluated the carcinogenic potential of inhalation of nickel dusts, it has not evaluated the oral carcinogenic potential for the soluble salts of nickel that are found in soils and sediments. Thus, no CSF has been developed.

### 5.6.2 Noncancer

USEPA has published a chronic oral RfD of 0.02 mg/kg-day for nickel in its IRIS database. The RfD is derived from a chronic oral study of rats conducted by Ambrose et al. (1976) in which rats displayed significantly decreased body weights after exposure. Rats were given 0, 5, 50, or 125 mg Ni/kg body weight daily in their diets for 2 years. Body weights were significantly reduced in males and females receiving the highest dose level, relative to the controls, and were also decreased in the 50 mg/kg group. In addition, female rats exhibited increased heart-to-body weight ratios and lower liver-to-body weight ratios in the 50 and 125 mg/kg treatment levels compared with controls. No effects were reported for the 5 mg/kg treatment level. The 50 mg/kg dose represents the LOAEL for this study while the 5 mg/kg dose represents the NOAEL.

These values were confirmed in a study by American Biogenics Corp. (ABC 1986) in which nickel chloride in water was administered to male and female rats for 90 days at levels of 0, 5, 35, and 100 mg/kg-day. ABC (1986) found that body weight and food consumption were greatly reduced for the 35 and 100 mg/kg-day treatment levels compared with controls. The 5 mg/kg-day treatment group showed no adverse effects, thereby supporting the 5 mg/kg-day NOAEL identified in the Ambrose et al. (1976) study.

A total uncertainty factor of 300 was applied to the NOAEL. This value included an uncertainty factor of 10 to account for interspecies extrapolation, another factor of 10 to address sensitive populations, and an uncertainty factor of 3 to account for inadequacies in the reproductive studies considered (RTI 1987; Smith et al. 1990).

Because no uncertainty factor was included by USEPA to address study duration, a subchronic RfD based on USEPA's chronic RfD cannot be derived. In addition, ATSDR (2005) does not provide an intermediate MRL for the oral exposure route for nickel. Thus, the chronic RfD of 0.02 mg/kg-day will be used to evaluate both chronic and subchronic exposures.

## **5.7 Thallium**

USEPA's 2011 IRIS database provides no toxicological criteria (i.e., CSF or RfDs) for thallium. However, a PPRTV has been derived by USEPA (Reid 2010) and is discussed below.

### **5.7.1 Cancer**

USEPA has deemed information on the carcinogenic potential of thallium to be inadequate to classify it. Therefore, no CSF is recommended.

### **5.7.2 Noncancer**

USEPA has developed a chronic PPRTV RfD of  $1 \times 10^{-5}$  mg/kg-day for thallium. This value is derived from an oral gavage study of rats conducted by Midwest Research Institute (MRI 1988). In this study, male and female rats were given 0, 0.01, 0.05, or 0.25 mg/kg-day of aqueous thallium sulfate (approximately 0, 0.008, 0.04, and 0.20 mg/kg-day, respectively) by gavage for 90 days. A number of parameters were measured including hematologic and clinical chemistry parameters, gross pathological observations, and neurotoxicological endpoints. Complete histopathological examinations were conducted for the vehicle control and 0.25 mg/kg-day group only. For the other three groups, histopathological examinations were conducted of the liver, lungs, kidneys, and gross lesions only. No treatment related effects were seen in the histopathological examinations. Lacrimation, exophthalmos, and miosis were all seen at increased levels in treated male and female rats, although examination of the eyes revealed no abnormalities. Clinical observation also recorded increased rough

coat, piloerection, shedding, and alopecia, as well as aggression, tension/agitation, hyperactivity, vocalization, and self-mutilation in male and female rats at higher doses.

While the study's authors concluded that the highest dose of 0.2 mg/kg-day was the NOAEL, USEPA characterized the high dose as a LOAEL rather than a NOAEL, using hair follicle atrophy in female rats that also had alopecia as the endpoint. Because rats in the low and mid-dose groups were not examined for histopathological changes in skin tissue, USEPA concluded that a NOAEL could not be accurately derived, but determined that, due to the low incidence of hair follicle atrophy in female rats and its lack in male rats, the mid-dose of 0.04 mg/kg-day was a reasonable approximation of the NOAEL.

The chronic noncancer PPRTV for thallium ( $1 \times 10^{-5}$  mg/kg-day) was based on this dose level and endpoint and derived using a combined uncertainty factor of 3,000. An interspecies factor of 10 was used for extrapolation from animals to humans. An intraspecies factor of 10 was used to account for variability in susceptible human populations. A database factor of 10 was applied to account for lack of adequate developmental studies and a two-generation study. A final uncertainty factor of 3 was applied to account for extrapolation from subchronic to chronic exposure. As such the subchronic RfD for oral thallium exposure is  $4 \times 10^{-5}$  mg/kg-day.

## **5.8 Zinc**

USEPA has not developed a CSF for zinc. However, the IRIS database provides a chronic RfD for zinc. This value, and the study upon which it is based, is discussed below.

### **5.8.1 Cancer**

USEPA lists zinc as a Class D carcinogen (not classifiable) based on inadequate or inconclusive human and animal data. Thus, no CSF has been developed.

### **5.8.2 Noncancer**

USEPA has established a chronic oral RfD of 0.3 mg/kg-day for zinc in its IRIS database. This value is based upon human clinical studies to establish daily nutritional requirements. Multiple studies have reviewed effects of zinc deficiency, including diarrhea, alopecia,

mental disturbances, growth retardation, and mental lethargy, among others (Abernathy et al. 1993; Prasad 1993; Sandstead 1994; Walsh et al. 1994). However, few studies have looked at zinc overdose. Four studies, named as co-principal studies in the IRIS database, looked at the effects of differing levels of dietary zinc intake. Using erythrocyte copper-zinc superoxide dismutase (ESOD) activity as a common endpoint, USEPA identified an oral RfD.

In a study by Yadrick et al. (1989) a group of healthy adult women were given 50 mg supplemental Zn/day. Combined with estimated average dietary zinc uptake, the total exposure level from the Yadrick et al. (1989) study was 59.38 mg Zn/day, or 0.99 mg Zn/kg-day assuming a 60 kg body weight. Over the course of the 10-week study, a significant 53 percent decrease in ESOD activity was seen. Another study by Fischer et al. (1984), gave 13 healthy adult males 0 mg or 25 mg zinc, orally, twice a day for 6 weeks. Combined with average daily diet consumption, total zinc intake for the 6-week period was 65.92 mg Zn/day, or 0.94 mg Zn/kg-day assuming a 70 kg body weight. Non-fasting blood samples were taken biweekly to examine copper status. Copper levels and feroxidase activity did not change. However, ESOD activity decreased after 4 weeks and was significantly lower than the control after 6 weeks. In addition, two studies by Davis et al. (2000) and Milne et al. (2001) examined exposure of a group of post-menopausal women, ages 50–76, to varying concentrations of dietary copper and zinc. Subjects were kept in a metabolic ward for 200 days, and fed a controlled basal diet of 0.6 mg Cu/day and 3 mg Zn/day. The first 10 days of the study consisted of an equilibration period in which subjects consumed an additional 1.4 mg Cu/day and 6 mg Zn/day. After the equilibration period, one group was exposed to a total of 1.0 mg Cu/day and another to a total of 3.0 mg Cu/day for 90 days. After the 90-day period, the copper diets were continued but an additional 50 mg Zn/day was added to both diets for another 90 days. The two 90-day periods were separated by an equilibration period similar to the original equilibration period. ESOD activity was significantly decreased relative to equilibration levels in low-copper treatment subjects and significantly increased in high-copper treatment subjects. However, zinc addition in the second 90-day period caused an insignificant decrease in ESOD activity in both treatment groups.

Evaluating results from all four studies, using common physiological endpoints at similar dose levels of 0.81 to 0.99 mg Zn/kg-day, USEPA generated an average effect level of

0.91 mg/kg-day. An uncertainty factor 3 was applied to account for intraspecies-variability in human populations. This yielded a chronic oral RfD of 0.3 mg/kg-day.

USEPA's IRIS database has no subchronic oral RfD for zinc. While ATSDR presents an intermediate minimal risk level of 0.3 mg/kg-day, this value is the same as the chronic RfD listed in IRIS and is based on the same principal study (Yadrick et al. 1989). Thus, the chronic RfD of 0.3 mg/kg-day will be used to evaluate both chronic and subchronic exposures, as appropriate.

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## 6 EVALUATION OF UNCERTAINTY IN SELECTED CRITERIA

The specific uncertainties associated with the COPCH-specific toxicological criteria that have been selected for use in the BHHRA are discussed in previous sections. There are additional sources of uncertainty that are common to most toxicological criteria selected, regardless of whether they address carcinogenic or noncarcinogenic effects. For example, toxicity of low levels of environmental constituents to humans cannot typically be measured but must be estimated based on the results of animal studies, *in vitro* or *in vivo* methods, or high-dose epidemiological evidence. Other uncertainties common to many toxicological criteria include deficiencies in the studies upon which they are based, approaches used to extrapolate from the study species to humans, uncertainty and modifying factors that are used to adjust study results to reflect variations within the human population, methods used to extrapolate from high study dose levels to more typical environmental exposure levels, and route-to-route extrapolation. In the context of these uncertainties, toxicological criteria are typically developed in a conservative manner to overestimate rather than underestimate potential effects in humans.

This section presents a summary of the types of uncertainty surrounding the selected criteria and discusses the manner in which those uncertainties will be evaluated in the BHHRA. Additional discussion of chemical toxicity in the context of the risk assessment results, and additional uncertainty analyses, will be provided in the BHHRA.

### 6.1 The Actual No-Effects Level

Toxicological criteria are generally derived on the basis of either laboratory animal studies or epidemiological studies in humans. For noncancer effects, the RfD is typically calculated by first identifying the NOAEL in the study subjects. If a NOAEL cannot be identified from the study, a LOAEL may be used. However, animal studies are generally designed to include a wide range of doses so that there may be substantial differences among dose levels. Thus, while a low dose may be identified as a NOAEL, and the next higher dose identified as the LOAEL, the actual NOAEL may be substantially higher (approaching the LOAEL). If this is the case, then the actual NOAEL will be overestimated and the result will be an RfD that is lower than necessary.

## **6.2 Differences in Species Sensitivities**

As discussed in Section 3.2, once a NOAEL or LOAEL has been identified, uncertainty and modifying factors are used to provide additional safety margins to account for differences in sensitivities, study duration, and other data limitations. Assumptions are made about each of these in identifying the selected uncertainty and modifying factors, generally with limited or no specific data to support them. So while it is generally assumed, for example, that humans are more sensitive than study animals to the toxic effects of certain compounds, there is substantial evidence to indicate that this is not always the case. If, in fact, human sensitivity to a particular compound is lower than the sensitivity exhibited in the animals studied, then such an adjustment will overestimate actual toxicity to humans.

## **6.3 Confounding Factors in Epidemiological Data**

Similar uncertainties are associated with toxicological criteria based on epidemiological data. Although human epidemiological data are of most relevance when evaluating human health risks, they are seldom adequate to provide a strong scientific basis for deriving specific toxicological criteria. This is because actual dose levels are generally unknown and thus can only be estimated. In addition, there are often exposures to multiple compounds or lifestyle choices that confound the establishment of a causal relationship between an individual chemical and the health endpoint of interest. In addition, the studied population is often too small to demonstrate a reliable causal association.

## **6.4 Linear vs. Nonlinear Dose Response**

For the cancer endpoint, a CSF is derived using the dose response curve from the study upon which it is based. Because dose levels in most studies are substantially higher than doses that would be experienced in environmental settings, it is necessary to make assumptions about what happens between the lowest dose level tested in the study and the zero dose level. USEPA assumes that there is a linear dose response in this region so that any dose, no matter how small, will result in some risk of cancer. As discussed in Section 4.1, there is growing evidence for certain carcinogenic compounds that this assumption is incorrect and that there is a threshold dose below which no cancer causation would be expected. For these constituents, use of a linear extrapolation model in estimating a CSF would overestimate risks associated with doses below that threshold.

In addition, even if one uses a linear dose response model, the results can be quite different depending upon the specific linear extrapolation model used and the assumptions made in making that extrapolation. As discussed in Section 4.1.3.1, CSFs for TCDD ranging from 9,700 to 156,000 (mg/kg-day)<sup>-1</sup> have been developed on the basis of data from the same animal study, but vary by more than an order of magnitude due to the specific extrapolation model employed, the animal-to-human scaling factor used, and the tumor classification incorporated. Thus, there are substantial uncertainties in all of these estimates and the true value is not known.

## **6.5 Other COPC<sub>HS</sub>**

There are a number of COPC<sub>HS</sub> for which USEPA has either not evaluated carcinogenic potential or there are inadequate, route-specific data to develop a quantitative estimate of their carcinogenic potential. These COPC<sub>HS</sub> will not be included in the calculation of potential cancer risks at the Site. However, the potential for risk estimates to be underestimated due to the exclusion of these COPC<sub>HS</sub> will be discussed qualitatively.

## **6.6 Lack of Toxicological Criteria for Dermal Uptake**

While it will be necessary to evaluate risks due to both oral and dermal exposures to the COPC<sub>HS</sub>, specific dermal CSFs have not been developed for any of the carcinogenic compounds that will be included in the BHHRA. In the absence of dermal toxicological criteria, USEPA (2004a) recommends using the oral toxicological criteria. Oral toxicological criteria are expressed as administered doses, whereas the exposure estimates for the dermal pathway are expressed as absorbed doses. For certain chemicals, the oral toxicity value is adjusted to represent an absorbed rather than administered dose. This adjustment accounts for the absorption efficiency in the critical study that forms the basis of the oral toxicity value (USEPA 2004a). When the oral absorption in the critical study is greater than 50 percent, it is assumed that the absorbed dose is equivalent to the administered dose, and USEPA (2004a) does not require an adjustment.

Route-to-route extrapolation assumes that once a chemical is absorbed into the bloodstream, the health effects are similar regardless of whether the route of exposure is oral or dermal.

This assumption may be valid for some chemicals with pharmacokinetic characteristics that are similar, regardless of route of administration; however, for many chemicals, factors such as absorption, metabolism, distribution, and elimination vary by exposure route, potentially leading to substantial differences in toxicity and contributing to uncertainties in risk estimates when route-specific toxicological criteria are not used.

## **6.7 Absence of Subchronic Toxicological Criteria**

Subchronic toxicological criteria are not available in USEPA's IRIS database for any of the COPCHs. As a result, it is necessary to make assumptions about appropriate subchronic toxicity. As indicated in Section 3.3 and Table 3, three approaches were used to derive subchronic toxicological criteria. If a subchronic value was available in a Tier 1, 2, or 3 source, that value was selected. If no subchronic toxicity value was available but the chronic toxicity value was based on a subchronic study, the uncertainty factor used to adjust the RfD from a subchronic study to a chronic study was removed to derive a subchronic toxicity value. This was the approach used for PCBs, BEHP, chromium(VI), mercuric chloride, and thallium. Finally, if there was no subchronic toxicity value and the chronic value was not based on a subchronic study, the chronic toxicity value was selected as a conservative surrogate to evaluate both chronic and subchronic exposures. For this last group, it is likely that hazards due to subchronic exposures will be overestimated.

## **6.8 Variability in Exposures and Toxicity**

The evaluation of uncertainties associated with the toxicological criteria used in the BHHRA will include both qualitative and quantitative methods, such as probabilistic risk assessment, depending on the quantity and quality of available data. Probabilistic risk assessment is a statistical technique that allows quantitative analysis of variability and uncertainty to be incorporated into exposure and/or risk assessments (USEPA 2001b, 2009c). The quantitative analysis of uncertainty and variability provides a more comprehensive characterization of risk than is possible in a deterministic (point estimate) approach. The resulting information on the distribution of risks and populations can be extremely valuable in risk management decision-making. Probabilistic risk assessment is typically part of a tiered approach that builds on the results of the point estimate risk assessment, and focuses on the exposure scenarios and chemicals that drive site-related risk. As recommended by USEPA guidance

(USEPA 2001b), the need for and scope of a probabilistic risk assessment will be considered after completion of the deterministic risk assessment.

As discussed in Section 4.1 there are a number of different CSFs, TDIs, and RfDs that have either been published or proposed for dioxin. In addition, USEPA has proposed an alternative CSF for arsenic (Section 5.1.3). The uncertainties around these toxicological criteria are substantial and can have a profound effect on the risks and hazards estimated in the BHHRA. For that reason, a quantitative uncertainty analysis will be presented that will demonstrate the differences in risk and hazard estimates depending upon the toxicological criteria used. This will provide risk managers with a description of the full range of potential risks and hazards upon which to make risk management decisions.

## **6.9 Toxicological Criteria for TCDD and Related Chemicals**

It is anticipated that the vast majority of potential site-related risks and hazards will be associated with exposures to DLCs in soils, sediment, and fish tissues. As discussed in Section 4.1, there is substantial uncertainty associated with the toxicological criteria that have been developed for TCDD and would be applied to TEQ concentrations. In addition, a number of different toxicological criteria have been developed by agencies worldwide to evaluate the noncancer effects of TCDD, including ATSDR's (1998) MRL of 1 pg/kg-day, the WHO (1998) TDI range of 1 to 4 pg/kg-day, and JECFA's (2002) TDI of 2.3 pg/kg-day. A deterministic sensitivity analysis will be conducted to demonstrate the effects of differing assumptions about the toxicity of TCDD on the estimated risks and hazards. In addition, a probabilistic analysis may be conducted that incorporates the range of toxicological criteria for TCDD to more clearly demonstrate the degree to which risk estimates are affected by the assumptions about its toxicity.

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## TABLES

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**Table 1**  
**Chemicals of Potential Concern for Human Health**

<b>COPC<sub>H</sub></b>
<b>Dioxins/Furans</b>
Dioxins and Furans
<b>Metals</b>
Arsenic
Cadmium
Chromium
Copper
Mercury
Nickel
Thallium
Zinc
<b>Polychlorinated Biphenyls</b>
Polychlorinated Biphenyls
<b>Semivolatile Organic Compounds</b>
Bis(2-ethylhexyl)phthalate

**Notes**

COPC<sub>H</sub>s shown are for the area north of I-10 and the aquatic environment. Selection of COPC<sub>H</sub>s for the south impoundment area is in progress at the time of this submittal (Jan. 2012). Although thallium is not a COPC<sub>H</sub> according to analyses of information for the north impoundment, the maximum concentration of thallium measured in the south impoundment area exceeded the screening value for workers and, therefore, may be a COPC<sub>H</sub> for the south impoundment.

COPC<sub>H</sub> = chemical of potential concern to be addressed in the baseline human health risk assessment

**Table 2**  
**Summary of Toxicity Criteria for the Cancer Endpoint**

Chemical of Potential Concern	Provisional Tolerable Oral Daily Intake/Oral Cancer Slope Factor	Units	USEPA Weight of Evidence/ Cancer Guideline Description	Target Organ/Effect	Date of Most Recent Update (MM/DD/YY)
2,3,7,8-TCDD <sup>a</sup>	2.3	pg/kg-day	B2	Developmental	2002
Polychlorinated biphenyls	2 (upper); 1 (central) <sup>b</sup>	(mg/kg-day) <sup>-1</sup>	B2	Liver	6/1/1997
Bis(2-ethylhexyl)phthalate	0.014	(mg/kg-day) <sup>-1</sup>	B2	Liver	2/1/1993
Arsenic (inorganic)	1.5	(mg/kg-day) <sup>-1</sup>	A	Skin, liver, lung, kidney, bladder	4/10/1998
Cadmium	--	--	B1 (inhalation only)	--	6/1/1992
Chromium(III)	--	--	D	--	9/3/1998
Chromium(VI)	Not determined <sup>c</sup>	--	D (oral)	--	9/3/1998
Copper	--	--	D	--	8/1/1991
Nickel	--	--	Not evaluated	--	8/1/1994
Methylmercury	--	--	C	--	5/1/1995
Mercury (inorganic)	--	--	D	--	5/1/1995
Thallium	--	--	Inadequate	--	9/30/2009
Zinc	--	--	D	--	8/3/2005

**Notes**

-- = no value available

a - This value will be used to evaluate the summed toxic equivalents of 2,3,7,8-substituted dioxins, 2,3,7,8-substituted furans and dioxin-like polychlorinated biphenyl congeners. It is based on the JECFA (2002) recommended provisional tolerable monthly intake for all potential health effects including cancer, adjusted to reflect a daily intake. (See text.)

b - USEPA's IRIS database provides both an upper bound and a central tendency cancer slope factor for PCBs. These will be used for the reasonable maximum exposure and central tendency exposure risk calculations, respectively.

c - USEPA has not developed an oral cancer slope factor for chromium(VI) stating that there were no data available to suggest that chromium(VI) is carcinogenic by the oral route of exposure.

**Table 3**  
**Summary of Toxicity Criteria for Noncancer Endpoints**

Chemical of Potential Concern	Chronic Oral RfD Value	Units	Sources of Chronic RfD	Combined Uncertainty/Modifying Factors: Chronic	Subchronic Oral RfD Value	Sources of Subchronic RfD: Target Organ	Combined Uncertainty/Modifying Factors: Subchronic	Primary Target Organ	Dates of Most Recent Update (MM/DD/YY) <sup>a</sup>
2,3,7,8-TCDD and DLCs	0.7	pg/kg-day	IRIS	30	0.7	IRIS <sup>b</sup>	30	Thyroid/sperm count and motility	2/17/2012
Polychlorinated biphenyls (Aroclor 1254)	2x10 <sup>-5</sup>	mg/kg-day	IRIS	300	6x10 <sup>-5</sup>	calculated <sup>c</sup>	100	Immune system	11/1/1996
Polychlorinated biphenyls (Aroclor 1016)	7x10 <sup>-5</sup>	mg/kg-day	IRIS	100	2x10 <sup>-4</sup>	calculated <sup>c</sup>	-	Reproductive/ developmental	11/1/1996
Bis(2-ethylhexyl)phthalate	0.02	mg/kg-day	IRIS	1,000	0.6	calculated <sup>c</sup>	300	Liver	5/1/1991
Arsenic (inorganic)	3x10 <sup>-4</sup>	mg/kg-day	IRIS	3	3x10 <sup>-4</sup>	IRIS <sup>b</sup>	-	Hyperpigmentation, keratosis, possible vascular	2/1/1993
Arsenic (organic)	0.01	mg/kg-day	ATSDR	100	0.1	ATSDR (diarrhea)	100	Kidney	8/1/2007
Cadmium (food)	0.001	mg/kg-day	IRIS	10	0.001	IRIS <sup>b</sup>	-	Kidney - Food <sup>d</sup>	2/1/1994
Cadmium (water)	5x10 <sup>-4</sup>	mg/kg-day	IRIS	10	5x10 <sup>-4</sup>	IRIS <sup>b</sup>	-	Kidney - Water <sup>d</sup>	2/1/1994
Chromium(III)	1.5	mg/kg-day	IRIS	1,000	1.5	IRIS <sup>b</sup>	-	No effects	9/3/1998
Chromium(VI)	0.003	mg/kg-day	IRIS	900	0.008	calculated <sup>c</sup>	300	No effects	9/3/1998
Copper	0.04	mg/kg-day	HEAST	NA	0.04	HEAST <sup>b</sup>	-	Gastrointestinal system	7/3/1997
Nickel	0.02	mg/kg-day	IRIS	300	0.02	IRIS <sup>b</sup>	-	Decreased organ and body weight	12/1/1996
Mercury (inorganic)	3x10 <sup>-4</sup>	mg/kg-day	IRIS	1,000	3x10 <sup>-3</sup>	calculated <sup>c</sup>	100	Autoimmune effects	5/1/1995
Methylmercury	1x10 <sup>-4</sup>	mg/kg-day	IRIS	10	1x10 <sup>-4</sup>	IRIS <sup>b</sup>	-	Neuropsychological	7/27/2001
Thallium	1x10 <sup>-5</sup>	mg/kg-day	PPRTV	3,000	4x10 <sup>-5</sup>	calculated <sup>c</sup>	1,000	Dermal effects	10/8/2010
Zinc	0.3	mg/kg-day	IRIS	3	0.3	IRIS <sup>b</sup>	-	Decrease in ESOD activity	8/3/2005

**Notes**

ATSDR = Agency for Toxic Substances and Disease Registry

DLCs = dioxin-like compounds

ESOD = erythrocyte Cu/Zn superoxide dismutase

HEAST = Health Effects Assessment Summary Tables

IRIS = Integrated Risk Information System

NA = Information not available in HEAST

PPRTV = provisional peer reviewed toxicity value

RfD = reference dose

TSH = thyroid stimulating hormone

a - Dates for chronic and subchronic values are the same unless otherwise indicated.

b - No subchronic RfD is available. The chronic RfD will be used.

c - Derivation of the chronic RfD included a factor to adjust for less than lifetime exposure. This value has been removed to derive the subchronic RfD.

d - Food values will be used for fish tissue and direct pathway analysis and water values will be used for incidental ingestion of surface water while swimming.

**Table 4**  
**Mammalian Toxicity Equivalency Factors for PCDDs, PCDFs, and PCBs**

Compound	TEF
<b>PCDDs</b>	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
All HxCDDs	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
<b>PCDFs</b>	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
All HxCDFs	0.1
All HpCDFs	0.01
OCDF	0.0003
<b>PCBs</b>	
3,3',4,4'-Tetrachlorinated biphenyl (PCB-77)	0.0001
3,4,4',5-Tetrachlorinated biphenyl (PCB-81)	0.0003
3,3',4,4',5-Pentachlorinated biphenyl (PCB-126)	0.1
3,3',4,4',5,5'-Hexachlorinated biphenyl (PCB-169)	0.03
2,3,3',4,4'-Pentachlorinated biphenyl (PCB-105)	0.00003
2,3,4,4',5-Pentachlorinated biphenyl (PCB-114)	0.00003
2,3',4,4',5-Pentachlorinated biphenyl (PCB-118)	0.00003
2',3,4,4',5-Pentachlorinated biphenyl (PCB-123)	0.00003
2,3,3',4,4',5-Hexachlorinated biphenyl (PCB-156)	0.00003
2,3,3',4,4',5'-Hexachlorinated biphenyl (PCB-157)	0.00003
2,3',4,4',5,5'-Hexachlorinated biphenyl (PCB-167)	0.00003
2,3,3',4,4',5,5'-Heptachlorinated biphenyl (PCB-189)	0.00003

**Source**

Van den Berg et al. (2006)

**Notes**

PCB = polychlorinated biphenyl

PCDD = polychlorinated dibenzo-*p*-dioxin

PCDF = polychlorinated dibenzofuran

TCDD/TCDF = tetrachlorinated dibenzodioxins/furans

PeCDD/PeCDF = pentachlorinated dibenzodioxins/furan

HxCDD/HxCDF = hexachlorinated dibenzodioxins/furans

HpCDD/HpCDF = heptachlorinated dibenzodioxins/furans

OCDD/OCDF = octachlorinated dibenzodioxins/furans

**Table 5**  
**PCB Congeners for Inclusion in Total PCB Summation**

PCB-8	PCB-81 <sup>a</sup>	PCB-128	PCB-177
PCB-18	PCB-87	PCB-138	PCB-180
PCB-28	PCB-99	PCB-151	PCB-183
PCB-37	PCB-101	PCB-153	PCB-187
PCB-44	PCB-105 <sup>a</sup>	PCB-156 <sup>a</sup>	PCB-189 <sup>a</sup>
PCB-49	PCB-110	PCB-157 <sup>a</sup>	PCB-194
PCB-52	PCB-114 <sup>a</sup>	PCB-158	PCB-195
PCB-66	PCB-118 <sup>a</sup>	PCB-167 <sup>a</sup>	PCB-201
PCB-70	PCB-119	PCB-168	PCB-206
PCB-74	PCB-123 <sup>a</sup>	PCB-169 <sup>a</sup>	PCB-209
PCB-77 <sup>a</sup>	PCB-126 <sup>a</sup>	PCB-170	

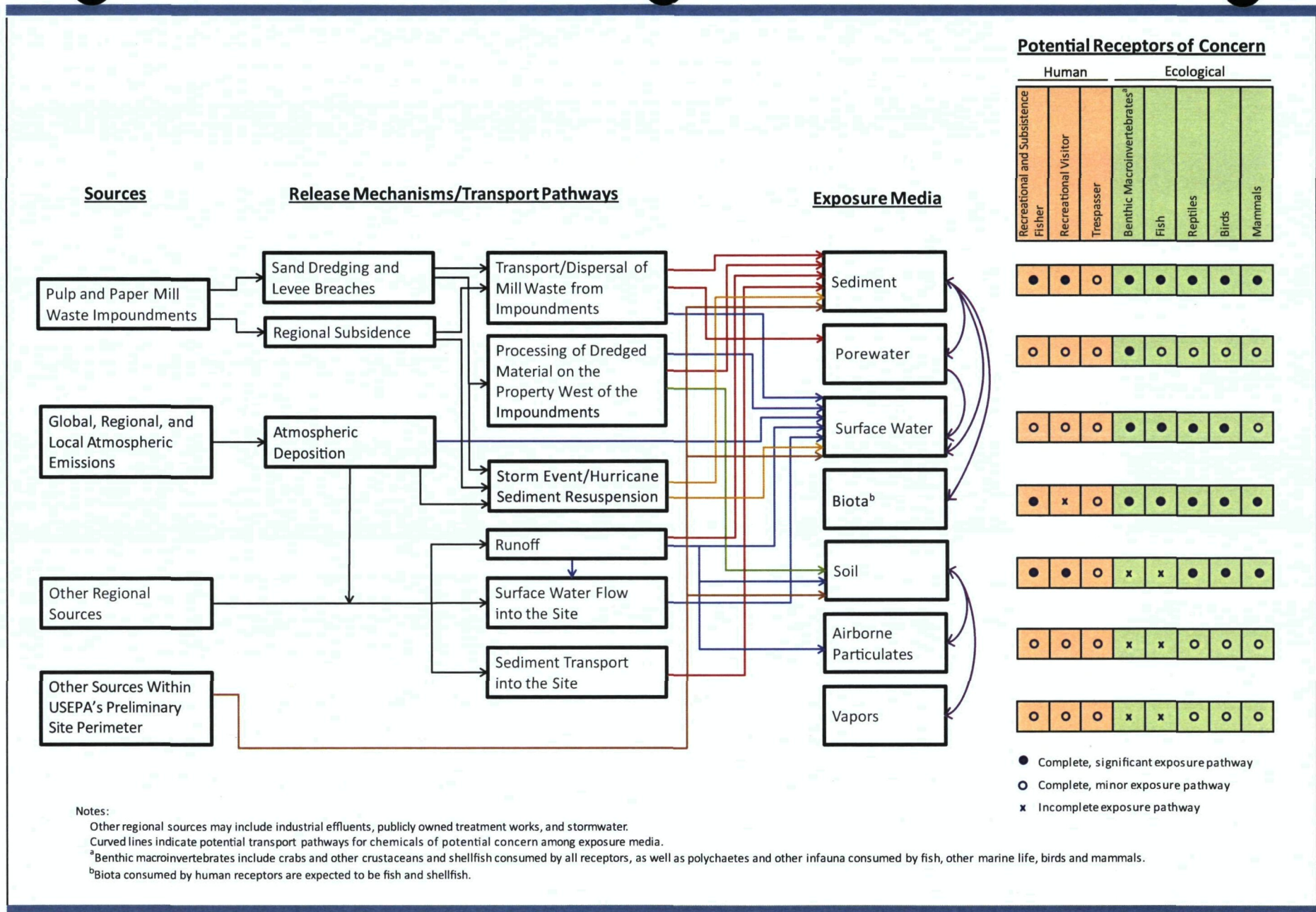
**Notes**

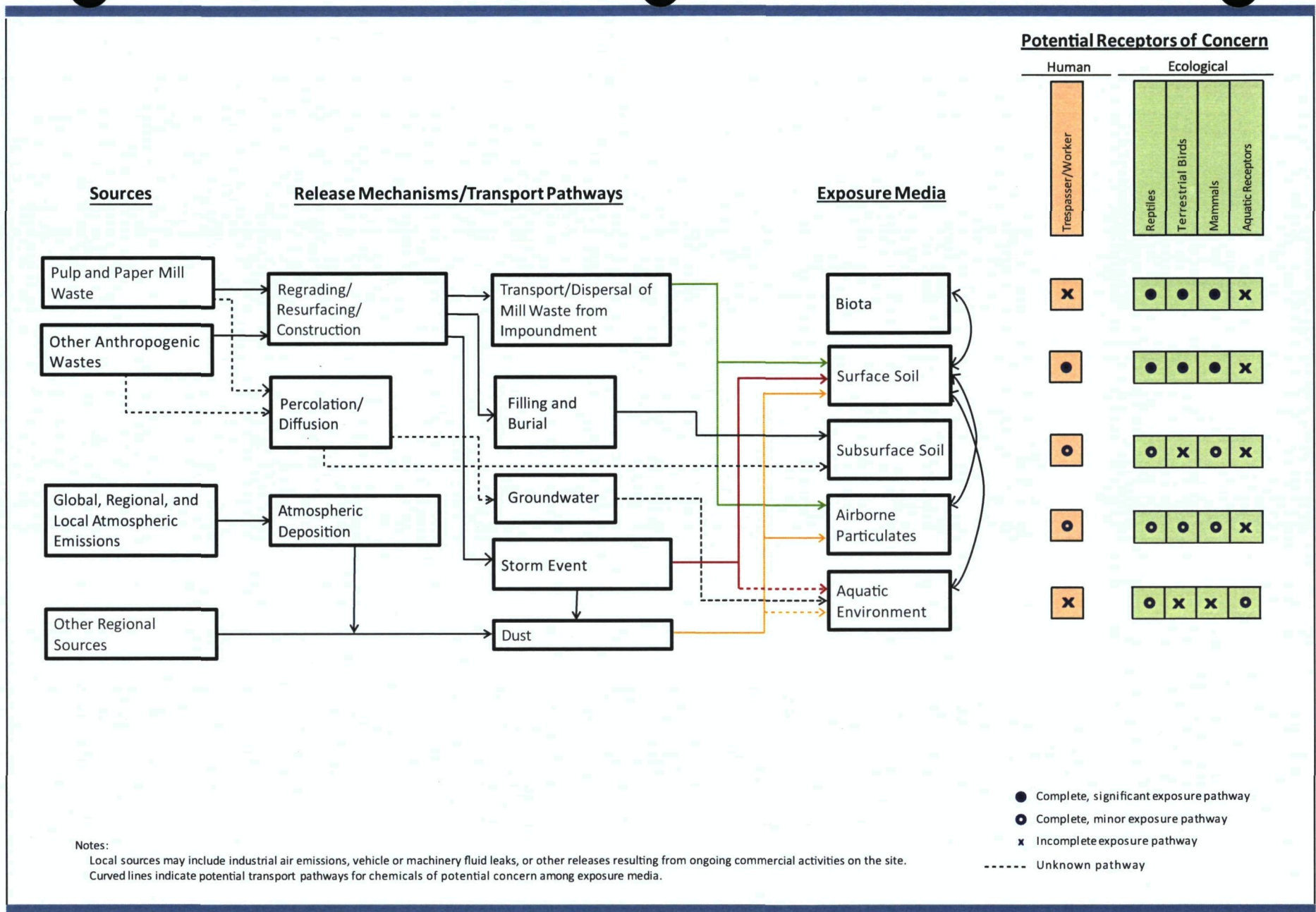
PCB = polychlorinated biphenyl

a - Dioxin-like congeners to be included in the toxic equivalency (TEQ) calculation

## FIGURES

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APPENDIX A  
EPA COMMENTS RELATING TO THE  
DRAFT TOXICOLOGICAL AND  
EPIDEMIOLOGICAL STUDIES  
MEMORANDUM, AND RESPONSES

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EPA Comments Relating to the Draft Toxicological and Epidemiological Studies Memorandum, and Responses

Comment No.	Section	Page	Comment	Response to Comment - Proposed Revision
1	2.1	2-1	This section identifies metals and inorganics as potential concerns for human health (also Table 1 of this document). However, this list is not completely reflective of the list identified in the Preliminary Site Characterization Report (Table 1-2). The text shall provide the rationale for not including the previously identified constituents of concern.	<p>The difference between Table 1 of the Toxicological and Epidemiological Memorandum (TES Memo), and the list of chemicals of potential concern (COPCs) for the Baseline Human Health Risk Assessment (BHHRA) provided in the Preliminary Site Characterization Report (PSCR) (i.e., the inclusion of thallium in Table 1 of the TES Memo) is clearly explained in Section 2.1, as follows:</p> <p>"Analyses of the sediment data according to methods described in the Sediment SAP are documented in the COPC Technical Memorandum (Integral 2011a) and resulted in determination of the final list of COPC<sub>H</sub>s for the area north of I-10 and the aquatic environment (Table 1). Selection of COPC<sub>H</sub>s for the south impoundment area is in progress. According to a comparison of the Phase I soil investigation results to risk-based human health screening levels protective of workers, only TEQ<sub>DF</sub>, arsenic, and thallium exceeded screening concentrations in all surface and subsurface samples for which they were analyzed (Integral 2011c, Attachment A). <b>Although thallium is not a COPC<sub>H</sub> according to analyses of information for the north impoundment, it may be determined to be a COPC<sub>H</sub> for the south impoundment, and is therefore addressed in this memorandum and listed in Table 1.</b>" (emphasis added)</p> <p>Chemicals to be addressed only for ecological receptors were listed in Table 1-2 of the the PSCR, but are not shown in the TES Memo, because the EA Memo only addresses human exposure analysis.</p>
2	2.2; Figure 1; Figure 2	2-2	This section discusses (and the Figures illustrate) exposure pathways and whether or not they are considered potentially complete. The exposure pathways from surface water to both fishers, recreational visitors, and trespassers, have been deemed complete/minor and therefore only qualitatively assessed. The report shall clarify and expand the qualitative assessment of these referenced pathways.	Text describing the manner in which minor pathways will be evaluated qualitatively will also be added to the final Exposure Assessment Memorandum (EA Memo).
4 <sup>a</sup>	3.3	3-6	The third bullet states, "if IRIS has no subchronic RfD and the chronic RfD is not based on a subchronic study, then ATSDR's intermediate MRL was selected as the toxicity criterion assuming that there is adequate scientific support provided." The text shall "define adequate scientific support", and what if adequate scientific support is not provided? The text shall elaborate and justify this statement.	<p>The Agency for Toxic Substances and Disease Registry's (ATSDR's) minimal risk levels (MRLs) are based on that agency's complete review of the toxicological database for the compound of interest and the selection of the study or studies deemed most appropriate by them as the basis for the MRLs. Full scientific support for its selection is provided in its Toxicological Profiles.</p> <p>The language "assuming there is adequate scientific support provided" will be deleted from the final TES Memo.</p>
5	4.1 and all relevant subsections		As EPA has just released the non-cancer assessment for dioxins/furans, this section and Table 3 shall be updated accordingly. The chronic oral RfD is now 0.7 pg/kg-day. In addition, please be aware that the cancer assessment may be finalized any day now.	Because the chronic oral reference dose (RfD) of 0.7 pg/kg-day has now been formally adopted by U.S. Environmental Protection Agency (USEPA) for the non-cancer assessment of dioxins and furans, it represents a Tier 1 toxicity value. The text of Section 4 and Table 3 will be updated accordingly.
6	4.1.2	4-7	This section mentions the EPA reference dose (RfD) for dioxin as proposed. It shall be noted that since the release of this document the EPA RfD for dioxin has been finalized.	The text of the TES Memo will be revised to address the finalization of USEPA's RfD for dioxin.
7	4.1.3.1.3	4-10	The last sentence of this section states, "No rationale for the preferential selection of the CalEPA value is provided in the documentation on USEPA's web site." The text shall note that the selection is due to the level of peer review as determined by the EPAs Regional Screening Levels Work Group.	The text will be updated to include this language.

EPA Comments Relating to the Draft Toxicological and Epidemiological Studies Memorandum, and Responses

Comment No.	Section	Page	Comment	Response to Comment - Proposed Revision
8	4.1.3.2	4-17	The RfD of 0.7 pg/kg-day has been adopted by EPA. This section shall be modified accordingly.	This section will be modified to address the RfD of 0.7 pg/kg-day that has now been formally adopted by USEPA.
9	4.2	4-21 and 4-22	This sentence states, "It is presumed that if USEPA adopts its proposed RfD for TCDD, it would recommend the same approach for evaluating the non-cancer effects of this subset of congeners." EPA has adopted the RfD for TCDD (0.7 pg/kg-day). The EPA however, has not made any policy statements yet as to this decision's effect on PCB assessment. This section shall be modified accordingly.	The text of the TES Memo will be modified to state that USEPA has not made any policy statements as to the effect of the final RfD for TCDD on the assessment of potential polychlorinated biphenyl (PCB) risks, and to clarify the approach in this context.
10	4.2	4-22	Though it may be true that treating all congeners in a similar fashion as the 12 dioxin-like compounds (DLC) may overestimate risk, the statement, "Thus, to combine the estimated TEQ risks for the 12 dioxin-like congeners with the estimated risks of the remaining congeners (calculated using USEPA's toxicological criteria for total PCBs) would effectively double-count the toxic potential of the dioxin-like PCB congeners.", is speculative and shall be removed or modified to provide scientific justification as to the "double-count" comment. It is not apparent that the scientific community has ascertained the toxic potential of the other 197 congeners combined in relation to the 12 DLCs. It could be more, less, or equal.	This statement will be modified to remove the reference to double-counting and to acknowledge uncertainties associated with the toxic potential of the non-dioxin-like PCB congeners.
11	7	7-14	The TCEQ 2011 citation is not correct. This reference was written by the Toxicology Division, which is located at TCEQ headquarters in Austin. The citation incorrectly gives Channelview, TX as the location. The citation shall give Austin, TX as the location.	The location of Texas Commission on Environmental Quality (TCEQ) headquarters will be corrected.
12	Table 3		Chromium (VI) and copper have the RfDs listed as 0.0025 and 0.037, respectively. This is not consistent with the text: Section 5.3.2.2 states the chromium (VI) RfD is 0.003, and Section 5.4.2 states the copper RfD is 0.04. The correct RfDs shall be used for calculations (i.e., the RfD stated in the text).	The RfDs reported in Table 3 for chromium (VI) and copper will be revised to match the RfDs reported in the text.
13	Table 3		The chronic oral RfD for dioxins shows 2.3 mg/kg-day, however, the units column shows pg/kg-day. This discrepancy shall be corrected.	The units for the RfD for dioxins will be clarified.
14	General		The document recounts the results of various studies and values obtained as background for the USEPA's final value/categorical determination. However, the intertwining of this information was at times confusing. The final outcome was stated in some instances, without the benefit of restating the value to be used (i.e. "the chronic RfD {for nickel} will be used to evaluate both chronic and subchronic exposures" ) without the benefit of restating that particular RfD. The text shall clearly provide the value to be used.	A concluding statement will be added to these discussions to clarify the specific toxicological values that will be used to evaluate chronic and subchronic exposures.

**Notes**

a – Original Comment 3 was withdrawn per a communication from Gary Miller, U.S. EPA, to David Keith, Anchor QEA, LLC, dated May 10, 2012, and has been omitted from this response to comments. Original comment numbers on subsequent comments are retained herein.

**References**

- Integral, 2011a. COPC Technical Memorandum, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Integral Consulting Inc., Seattle, WA. May.
- Integral, 2011c. Sampling and Analysis Plan: Soil Study, Addendum 3, San Jacinto River Waste Pits Superfund Site. Prepared for International Paper Company and U.S. Environmental Protection Agency, Region 6. Integral Consulting Inc., Seattle, WA. December.
- USEPA, 1989a. Risk Assessment Guidance for Superfund. Volume 1 Human Health Evaluation Manual (Part A).
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- U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002. December.

APPENDIX C  
SCREENING ANALYSIS FOR THE AREA OF  
INVESTIGATION ON THE PENINSULA  
SOUTH OF I-10

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# APPENDIX C

## SCREENING ANALYSIS FOR THE AREA OF INVESTIGATION ON THE PENINSULA SOUTH OF I-10

### SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

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#### **Prepared for**

McGinnes Industrial Maintenance Corporation  
International Paper Company  
U.S. Environmental Protection Agency, Region 6

#### **Prepared by**



Integral Consulting Inc.  
411 1st Avenue S, Suite 550  
Seattle, Washington 98104

**December 2012**

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Table C-6	Chemicals of Potential Concern for Human Health for Soil Investigation Area 4 and Adjacent Soil Samples

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## List of Acronyms and Abbreviations

Abbreviation	Definition
ALM	adult lead model
BaP	benzo(a)pyrene
COI	chemical of interest
COPCH	chemical of potential concern for human health
EAM	Exposure Assessment Memorandum
I-10	Interstate Highway 10
PRG	preliminary remediation goal
NHANES	National Health and Nutrition Surveys
SAP	sampling and analysis plan
Site	San Jacinto River Waste Pits Superfund site
USEPA	U.S. Environmental Protection Agency

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## 1 INTRODUCTION

This appendix presents the process and results of the screening analysis used to identify chemicals of potential concern for human health (COPCHs) for soil samples collected in the area of investigation on the peninsula south of Interstate Highway 10 (I-10) at the San Jacinto River Waste Pits site in Harris County, Texas (the Site).<sup>1</sup> This area consists of Soil Investigation Area 4 and adjacent sampled areas on the peninsula south of I-10, as depicted on Figure 2-15 of the Remedial Investigation Report and Figure 6-1 of the Baseline Human Health Risk Assessment Report.

Baseline risk assessments evaluate the potential threats to human health and the environment in the absence of any remedial action. To focus a risk assessment, it is necessary to identify those chemicals that are present at concentrations that might pose potential harm to receptors, rather than assess all chemicals that may be present on a site. The purpose of this appendix is to compile and screen all available soil data to identify COPCHs for the area of investigation on the peninsula south of I-10. The relevant background, screening process, and screening results are provided below.

## 2 BACKGROUND

### 2.1 Data

At the time the COPC Technical Memorandum (Integral 2011) was submitted, the soils in the area of investigation on the peninsula south of I-10 had not yet been fully characterized; therefore, the final list of COPCHs for soil in this area was not established in that document. In May 2012, additional soil samples were collected from this investigation area and analyzed for chemicals of interest (COIs). Addendum 3 to the Soil Sampling and Analysis Plan (SAP) for Additional Soil Sampling South of Interstate Highway I-10 outlines the Phase II sampling (Integral 2012b). Briefly, the Phase II sampling addressed uncertainties about the distribution of chemicals in the area of investigation on the peninsula south of I-10. Seventeen additional locations were sampled during the Phase II sampling effort, bringing the total number of sampling locations to 30 for this investigation area. At these locations,

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<sup>1</sup> References to "the Site" in this document are intended as reference to the formally designated Superfund site and not to a geographical area.

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samples were collected at various depth intervals, including 0–6 inches, 6–12 inches, 12–24 inches, 24–48 inches and then every 2 feet until the target borehole depth (typically 16 feet) was reached. These samples were analyzed for those chemicals identified in the COPC Technical Memorandum (Integral 2011), including metals, dioxin/furans, polychlorinated biphenyls, PAHs, and other semivolatile and volatile organics.

## **2.2 Human Use and Receptors**

The peninsula south of I-10 is developed and managed for commercial and industrial activity. As discussed in the Exposure Assessment Memorandum (EAM), hypothetical commercial adult workers and trespassers (ages 16 to 22 years of age) are the human receptors with potential for exposure in this area (Integral 2012a). Potential exposures for hypothetical commercial workers and trespassers to environmental media in this area are assumed to occur via direct contact with soil (i.e., incidental ingestion and dermal contact). Hypothetical trespassers might be exposed to surface soil (0–6 inches) and hypothetical commercial workers might be exposed to surface and shallow subsurface soil (0–12 inches).

## **3 SCREENING PROCESS**

COPCHS were identified according to steps described by the Remedial Investigation and Feasibility Study Work Plan (Anchor QEA and Integral 2010). Briefly, Phase I and Phase II soil data (surface and shallow subsurface) for the area of investigation on the peninsula south of I-10 were compiled. The frequency of detection for each chemical was calculated. Those chemicals detected in more than 5 percent of samples were identified as COIs this area of investigation (Table C-1). The list of COIs was further refined based on potential human receptors and assumed routes of exposure. For COIs identified from all soil data for this area of investigation, frequency of detection was calculated for chemicals in soils extending from 0 to 6 inches and from 0 to 12 inches for hypothetical trespassers and commercial workers, respectively. Those chemicals detected in more than 5 percent of the samples at the two depth intervals are referred to as receptor-specific COIs (Tables C-2 and C-3).

Maximum concentrations of receptor-specific COIs were then compared to industrial human health screening criteria for soils (Table C-4). A tiered approach was used to select the screening criteria, with Tier 2 values used only when Tier 1 criteria were not available:

- 
- Tier 1: USEPA May 2012 risk-based screening levels (USEPA 2012)
  - Tier 2: Texas Risk Reduction Program protective concentration levels (TCEQ 2011).

## 4 RESULTS

Table C-5 compares the receptor-specific COIs to the screening criteria. Arsenic, lead, benzo(a)pyrene (BaP), and dioxins and furans exceeded the screening values. The screening value for lead<sup>2</sup> of 800 mg/kg is based on U.S. Environmental Protection Agency's (USEPA) adult lead model (ALM), which assesses risks to adults from non-residential exposures to lead in soil. The ALM defaults to a hypothetical worker scenario, but it is appropriate for other non-residential scenarios, such as a hypothetical trespasser scenario. For assessing non-residential exposures, the ALM guidance (USEPA 2001) recommends a minimum exposure duration of 90 days and a minimum exposure frequency of one day per week. The lead preliminary remediation goal (PRG) corresponds to a geometric standard deviation and a background lead blood level from historical National Health and Nutrition Surveys (NHANES). Both of these parameters have been updated to reflect more recently available population data, and are recommended by USEPA (2009) for all applications of the ALM. USEPA's (2009) updated geometric standard deviation of 1.8 and a background blood lead level of 1.0 µg/dL from NHANES 1999–2004 were used in the calculations below.

Although the screening analysis identified lead as a COPCH, an evaluation of lead using the ALM demonstrates that allowable lead concentrations (i.e., PRGs) for the hypothetical trespasser and the commercial worker scenarios are higher than the maximum lead concentrations in either the surface or shallow subsurface soils. In the case of the hypothetical commercial worker scenario, the ALM was run, adjusting the assumed exposure frequency and soil ingestion rate to reflect those outlined in the EAM (Integral 2012a). Based on an exposure frequency of 225 days per year and an assumed soil ingestion rate of 100 mg/ day, the lead PRG is 1,090 mg/kg for the hypothetical worker. The maximum lead concentration in shallow subsurface soil is 896 mg/kg. This maximum concentration does not exceed the lead PRG modeled for the hypothetical commercial worker.

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<sup>2</sup> The screening lead level is referred to as a PRG.

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For the ALM model run for the hypothetical trespasser using model default values, an exposure frequency of 52 days/year (the minimum exposure frequency recommended as valid by USEPA) and an assumed soil ingestion rate of 41 mg/day (as outlined in the EAM, Integral 2012a) the resulting lead PRG is 11,503 mg/kg. This PRG corresponds to a lead absorption of 12 percent, the model default. Because there is a potential for lead absorption to be higher in adolescents than in adults, USEPA<sup>3</sup> recommends a lead absorption range of 12 to 30 percent for the adolescent. Running the ALM assuming 30 percent absorption, results in a lead PRG of 4,601 mg/kg. The maximum lead concentration in surface soil is 896 mg/kg. Therefore, whether 12 percent or 30 percent absorption is applied, this maximum concentration does not exceed the modeled lead PRGs for the hypothetical trespasser. It is also important to note that the minimum exposure frequency required for the ALM (52 days per year) is greater than the exposure frequency of 24 days per year for the hypothetical trespasser as outlined in the EAM (Integral 2012a).

Because lead PRGs for both the hypothetical trespasser and commercial worker scenarios are greater than the maximum lead concentrations measured in surface and shallow subsurface soils, further evaluation of lead for the area of investigation on the peninsula south of I-10 is not warranted. Therefore, although the maximum detected lead concentration exceeded the screening level, lead is not brought forward for the quantitative risk assessment. As summarized in Table C-6, the COPCHs that are evaluated in the quantitative assessment for both the hypothetical commercial worker and trespasser scenarios for the area of investigation on the peninsula south of I-10 are arsenic, dioxins and furans (TEQ<sub>DF</sub>), and BaP.

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<sup>3</sup> <http://www.epa.gov/superfund/lead/almfaq.htm>

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## 5 REFERENCES

- Anchor QEA and Integral, 2010. Remedial Investigation/Feasibility Study Work Plan, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company and U.S. Environmental Protection Agency, Region 6. Anchor QEA, Ocean Springs, MS and Integral Consulting Inc., Seattle, WA. September.
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- USEPA, 2001. Review of Adult Lead Models, Evaluation of Models for Assessing Human Health Risks Associated with Lead Exposures at Non-Residential Areas of Superfund and Other Hazardous Waste Sites. Final draft. OSWER #9285.7-46. Prepared by the Adult Lead Risk Assessment Committee of the Technical Review Workgroup for Lead (TRW). Office of Solid Waste and Emergency Response. United States Environmental Protection Agency, Washington, D.C. August.

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USEPA, 2003. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. Prepared by the Technical Review Workgroup for Lead (TRW). Office of Solid Waste and Emergency Response. United States Environmental Protection Agency, Washington, D.C. January.

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USEPA, 2012. USEPA Risk-Based Screening Levels for Industrial Soil. Last updated May 2012 and accessed at [http://www.epa.gov/reg3hwmd/risk/human/rb-concentration\\_table/Generic\\_Tables/index.htm](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm) on May 15, 2012.

## TABLES

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**Table C-1**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**

Analyte	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI
<b>Metals</b>					
Aluminum	7429-90-5	138	138	100	Y
Arsenic	7440-38-2	138	138	100	Y
Barium	7440-39-3	138	138	100	Y
Cadmium	7440-43-9	138	121	88	Y
Chromium	7440-47-3	138	138	100	Y
Cobalt	7440-48-4	138	138	100	Y
Copper	7440-50-8	138	138	100	Y
Lead	7439-92-1	138	138	100	Y
Magnesium	7439-95-4	137	137	100	Y
Manganese	7439-96-5	138	138	100	Y
Mercury	7439-97-6	138	136	99	Y
Nickel	7440-02-0	138	138	100	Y
Thallium	7440-28-0	138	54	39	Y
Vanadium	7440-62-2	138	138	100	Y
Zinc	7440-66-6	138	138	100	Y
<b>Polychlorinated Biphenyl Congeners</b>					
Total PCBs <sup>a</sup>	1336-36-3				
Total PCB Congeners		75	74	99	Y
<b>Organics</b>					
Dioxins and furans					
TEQ <sub>DF</sub> mammals		250	250	100	Y
Semivolatile Organic Compounds					
Acenaphthene	83-32-9	135	66	49	Y
Acenaphthylene	208-96-8	65	25	38	Y
Anthracene	120-12-7	65	33	51	Y
Benzo[a]anthracene	56-55-3	65	43	66	Y
Benzo[a]pyrene	50-32-8	65	43	66	Y
Benzo[b]fluoranthene	205-99-2	65	47	72	Y
Benzo[g,h,i]perylene	191-24-2	65	43	66	Y
Benzo[k]fluoranthene	207-08-9	64	33	52	Y
Benzoic acid	65-85-0	64	0	0	--
Benzyl alcohol	100-51-6	64	2	3	--
Bis(2-chloroethoxy)methane	111-91-1	65	0	0	--
Bis(2-chloroethyl) ether	111-44-4	65	0	0	--
Bis(2-chloroisopropyl) ether	39638-32-9	65	0	0	--
Bis(2-ethylhexyl) phthalate	117-81-7	137	89	65	Y
4-Bromophenyl phenyl ether	101-55-3	65	0	0	--
Butyl benzyl phthalate	85-68-7	65	28	43	Y
Carbazole	86-74-8	135	47	35	Y
4-Chloro-3-methylphenol	59-50-7	64	0	0	--
4-Chloroaniline	106-47-8	65	1	2	--
2-Chloronaphthalene	91-58-7	65	0	0	--
2-Chlorophenol	95-57-8	64	0	0	--
4-Chlorophenyl phenyl ether	7005-72-3	65	0	0	--

**Table C-1**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**

Analyte	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI
Chrysene	218-01-9	65	44	68	Y
Dibenzo[a,h]anthracene	53-70-3	65	26	40	Y
Dibenzofuran	132-64-9	65	5	8	Y
3,3'-Dichlorobenzidine	91-94-1	65	0	0	--
2,4-Dichlorophenol	120-83-2	136	0	0	--
Diethyl phthalate	84-66-2	65	0	0	--
Dimethyl phthalate	131-11-3	65	19	29	Y
2,4-Dimethylphenol	105-67-9	64	0	0	--
Di- <i>n</i> -butyl phthalate	84-74-2	65	16	25	Y
2,4-Dinitrophenol	51-28-5	64	0	0	--
2,4-Dinitrotoluene	121-14-2	65	0	0	--
2,6-Dinitrotoluene	606-20-2	65	0	0	--
Di- <i>n</i> -octyl phthalate	117-84-0	65	3	5	--
Fluoranthene	206-44-0	65	50	77	Y
Fluorene	86-73-7	135	64	47	Y
Hexachlorobenzene	118-74-1	135	3	2	--
Hexachlorocyclopentadiene	77-47-4	65	0	0	--
Hexachloroethane	67-72-1	65	0	0	--
Indeno[1,2,3- <i>cd</i> ]pyrene	193-39-5	65	43	66	Y
Isophorone	78-59-1	65	0	0	--
2-Methyl-4,6-dinitrophenol	534-52-1	64	0	0	--
2-Methylnaphthalene	91-57-6	65	20	31	Y
2-Methylphenol	95-48-7	64	0	0	--
4-Methylphenol	106-44-5	64	1	2	--
Naphthalene	91-20-3	142	64	45	Y
2-Nitroaniline	88-74-4	65	0	0	--
3-Nitroaniline	99-09-2	65	0	0	--
4-Nitroaniline	100-01-6	65	0	0	--
Nitrobenzene	98-95-3	65	0	0	--
2-Nitrophenol	88-75-5	64	0	0	--
4-Nitrophenol	100-02-7	63	0	0	--
N-Nitrosodi- <i>n</i> -propylamine	621-64-7	65	0	0	--
N-Nitrosodiphenylamine	86-30-6	65	1	2	--
Pentachlorophenol	87-86-5	135	0	0	--
Phenanthrene	85-01-8	135	108	80	Y
Phenol	108-95-2	136	17	13	Y
Pyrene	129-00-0	65	52	80	Y
2,4,5-Trichlorophenol	95-95-4	136	0	0	--
2,4,6-Trichlorophenol	88-06-2	136	0	0	--
<b>Volatile Organic Compounds</b>					
Acetone	67-64-1	72	38	53	Y
Benzene	71-43-2	72	69	96	Y
Bromobenzene	108-86-1	72	0	0	--
Bromochloromethane	74-97-5	72	0	0	--
Bromodichloromethane	75-27-4	72	0	0	--

**Table C-1**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**

Analyte	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI
Bromoform	75-25-2	72	0	0	--
Bromomethane	74-83-9	72	6	8	Y
2-Butanone	78-93-3	72	54	75	Y
<i>n</i> -Butylbenzene	104-51-8	72	20	28	Y
<i>sec</i> -Butylbenzene	135-98-8	72	21	29	Y
<i>tert</i> -Butylbenzene	98-06-6	72	3	4	--
Carbon disulfide	75-15-0	72	65	90	Y
Carbon tetrachloride	56-23-5	72	2	3	--
Chlorobenzene	108-90-7	72	13	18	Y
Chloroethane	75-00-3	72	2	3	--
Chloroform	67-66-3	144	16	11	Y
Chloromethane	74-87-3	72	9	13	Y
2-Chlorotoluene	95-49-8	72	0	0	--
4-Chlorotoluene	106-43-4	72	0	0	--
1,2-Dibromo-3-chloropropane	96-12-8	72	0	0	--
Dibromochloromethane	124-48-1	72	0	0	--
1,2-Dibromoethane	106-93-4	72	0	0	--
Dibromomethane	74-95-3	72	0	0	--
1,2-Dichlorobenzene	95-50-1	144	17	12	Y
1,3-Dichlorobenzene	541-73-1	144	26	18	Y
1,4-Dichlorobenzene	106-46-7	144	22	15	Y
Dichlorodifluoromethane	75-71-8	72	0	0	--
1,1-Dichloroethane	75-34-3	72	0	0	--
1,2-Dichloroethane	107-06-2	72	0	0	--
1,1-Dichloroethene	75-35-4	72	0	0	--
<i>cis</i> -1,2-Dichloroethene	156-59-2	72	1	1	--
<i>trans</i> -1,2-Dichloroethene	156-60-5	72	5	7	Y
1,2-Dichloropropane	78-87-5	72	0	0	--
1,3-Dichloropropane	142-28-9	72	0	0	--
2,2-Dichloropropane	594-20-7	72	2	3	--
1,1-Dichloropropene	563-58-6	72	0	0	--
<i>cis</i> -1,3-Dichloropropene	10061-01-5	72	0	0	--
<i>trans</i> -1,3-Dichloropropene	10061-02-6	72	0	0	--
Ethylbenzene	100-41-4	72	46	64	Y
Hexachlorobutadiene	87-68-3	72	0	0	--
2-Hexanone	591-78-6	72	1	1	--
Isopropylbenzene	98-82-8	72	36	50	Y
4-Isopropyltoluene	99-87-6	72	40	56	Y
4-Methyl-2-pentanone	108-10-1	72	3	4	--
Methylene chloride	75-09-2	72	0	0	--
<i>n</i> -Propylbenzene	103-65-1	72	30	42	Y
Styrene	100-42-5	72	8	11	Y
1,1,1,2-Tetrachloroethane	630-20-6	72	0	0	--
1,1,2,2-Tetrachloroethane	79-34-5	72	0	0	--
Tetrachloroethene	127-18-4	72	0	0	--

**Table C-1**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**

Analyte	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI
Toluene	108-88-3	72	67	93	Y
1,2,3-Trichlorobenzene	87-61-6	144	0	0	--
1,2,4-Trichlorobenzene	120-82-1	144	5	3	--
1,1,2-Trichloroethane	79-00-5	72	0	0	--
1,1,1-Trichloroethane	71-55-6	72	0	0	--
Trichloroethene	79-01-6	72	4	6	Y
Trichlorofluoromethane	75-69-4	72	1	1	--
1,2,3-Trichloropropane	96-18-4	72	0	0	--
1,2,4-Trimethylbenzene	95-63-6	72	47	65	Y
1,3,5-Trimethylbenzene	108-67-8	72	31	43	Y
Vinyl chloride	75-01-4	72	2	3	--
o-Xylene	95-47-6	72	45	63	Y
m,p -Xylenes	179601-23-1	72	59	82	Y

**Notes**

-- not applicable

COI = chemical of interest; detected in greater than 5 percent of soil samples collected in the area for investigation south of I-10 (all depths)

PCB = polychlorinated biphenyl

a = Total PCBs is the sum of 43 congeners.

**Table C-2**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**  
**0 to 6 inches<sup>a</sup>**

COI <sup>b</sup>	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI <sub>SI</sub> (0-6 inches)
<b>Metals</b>					
Aluminum	7429-90-5	22	22	100	Y
Arsenic	7440-38-2	22	22	100	Y
Barium	7440-39-3	22	22	100	Y
Cadmium	7440-43-9	22	22	100	Y
Chromium	7440-47-3	22	22	100	Y
Cobalt	7440-48-4	22	22	100	Y
Copper	7440-50-8	22	22	100	Y
Lead	7439-92-1	22	22	100	Y
Magnesium	7439-95-4	22	22	100	Y
Manganese	7439-96-5	22	22	100	Y
Mercury	7439-97-6	22	22	100	Y
Nickel	7440-02-0	22	22	100	Y
Thallium	7440-28-0	22	12	55	Y
Vanadium	7440-62-2	22	22	100	Y
Zinc	7440-66-6	22	22	100	Y
<b>Polychlorinated Biphenyl Congeners</b>					
Total PCBs <sup>c</sup>	1336-36-3				
Total PCB Congeners		11	11	100	Y
<b>Organics</b>					
<b>Dioxins and furans</b>					
TEQ <sub>DF</sub> mammals		26	26	100	Y
<b>Semivolatile Organic Compounds</b>					
Acenaphthene	83-32-9	21	14	67	Y
Acenaphthylene	208-96-8	11	5	45	Y
Anthracene	120-12-7	11	9	82	Y
Benzo[a]anthracene	56-55-3	11	11	100	Y
Benzo[a]pyrene	50-32-8	11	11	100	Y
Benzo[b]fluoranthene	205-99-2	11	11	100	Y
Benzo[g,h,i]perylene	191-24-2	11	11	100	Y
Benzo[k]fluoranthene	207-08-9	11	11	100	Y
Bis(2-ethylhexyl) phthalate	117-81-7	21	20	95	Y
Butyl benzyl phthalate	85-68-7	11	7	64	Y
Carbazole	86-74-8	21	13	62	Y
Chrysene	218-01-9	11	11	100	Y
Dibenzo[a,h]anthracene	53-70-3	11	10	91	Y

**Table C-2**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**  
**0 to 6 inches<sup>a</sup>**

COI <sup>b</sup>	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI <sub>SI</sub> (0–6 inches)
Dibenzofuran	132-64-9	11	1	9	Y
Dimethyl phthalate	131-11-3	11	5	45	Y
Di- <i>n</i> -butyl phthalate	84-74-2	11	4	36	Y
Fluoranthene	206-44-0	11	11	100	Y
Fluorene	86-73-7	21	13	62	Y
Indeno[1,2,3- <i>cd</i> ]pyrene	193-39-5	11	11	100	Y
2-Methylnaphthalene	91-57-6	11	5	45	Y
Naphthalene	91-20-3	20	11	55	Y
Phenanthrene	85-01-8	21	21	100	Y
Phenol	108-95-2	21	3	14	Y
Pyrene	129-00-0	11	11	100	Y
<b>Volatile Organic Compounds</b>					
Acetone	67-64-1	10	7	70	Y
Benzene	71-43-2	10	10	100	Y
Bromomethane	74-83-9	10	3	30	Y
2-Butanone	78-93-3	10	8	80	Y
<i>n</i> -Butylbenzene	104-51-8	10	1	10	Y
<i>sec</i> -Butylbenzene	135-98-8	10	0	0	--
Carbon disulfide	75-15-0	10	9	90	Y
Chlorobenzene	108-90-7	10	1	10	Y
Chloroform	67-66-3	20	1	5	--
Chloromethane	74-87-3	10	1	10	Y
1,2-Dichlorobenzene	95-50-1	20	0	0	--
1,3-Dichlorobenzene	541-73-1	20	0	0	--
1,4-Dichlorobenzene	106-46-7	20	0	0	--
<i>trans</i> -1,2-Dichloroethene	156-60-5	10	1	10	Y
Ethylbenzene	100-41-4	10	8	80	Y
Isopropylbenzene	98-82-8	10	3	30	Y
4-Isopropyltoluene	99-87-6	10	2	20	Y
<i>n</i> -Propylbenzene	103-65-1	10	3	30	Y
Styrene	100-42-5	10	0	0	--
Toluene	108-88-3	10	8	80	Y

**Table C-2**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**  
**0 to 6 inches<sup>a</sup>**

COI <sup>b</sup>	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI <sub>SI</sub> (0-6 inches)
Trichloroethene	79-01-6	10	0	0	--
1,2,4-Trimethylbenzene	95-63-6	10	6	60	Y
1,3,5-Trimethylbenzene	108-67-8	10	3	30	Y
<i>o</i> -Xylene	95-47-6	10	5	50	Y
<i>m,p</i> -Xylenes	179601-23-1	10	10	100	Y

**Notes**

-- not applicable

COI = chemical of interest; detected in greater than 5 percent of soil samples collected in the area for investigation south of I-10 (all depths)

COI<sub>SI</sub> = COI detected in greater than 5 percent of samples collected in the area for investigation south of I-10 at the depth interval of interest for risk evaluation.

a - The 0 to 6-inch depth interval pertains to the hypothetical trespasser human receptor.

b - Only chemicals identified as COIs based on frequency of detection soil data within the area for investigation south of I-10 (Table C-1) are included here.

c - Total PCBs is the sum of 43 congeners.

**Table C-3**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**  
**0 to 12 inches<sup>a</sup>**

COI <sup>b</sup>	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI <sub>SI</sub> (0–12 in)
<b>Metals</b>					
Aluminum	7429-90-5	43	43	100	Y
Arsenic	7440-38-2	43	43	100	Y
Barium	7440-39-3	43	43	100	Y
Cadmium	7440-43-9	43	42	98	Y
Chromium	7440-47-3	43	43	100	Y
Cobalt	7440-48-4	43	43	100	Y
Copper	7440-50-8	43	43	100	Y
Lead	7439-92-1	43	43	100	Y
Magnesium	7439-95-4	43	43	100	Y
Manganese	7439-96-5	43	43	100	Y
Mercury	7439-97-6	43	43	100	Y
Nickel	7440-02-0	43	43	100	Y
Thallium	7440-28-0	43	20	47	Y
Vanadium	7440-62-2	43	43	100	Y
Zinc	7440-66-6	43	43	100	Y
<b>Polychlorinated Biphenyl Congeners</b>					
Total PCBs <sup>c</sup>	1336-36-3				
Total PCB Congeners		22	22	100	Y
<b>Organics</b>					
<b>Dioxins and furans</b>					
TEQ <sub>DF</sub> mammals		52	52	100	Y
<b>Semivolatile Organic Compounds</b>					
Acenaphthene	83-32-9	41	24	59	Y
Acenaphthylene	208-96-8	22	11	50	Y
Anthracene	120-12-7	22	15	68	Y
Benzo[a]anthracene	56-55-3	22	21	95	Y
Benzo[a]pyrene	50-32-8	22	22	100	Y
Benzo[b]fluoranthene	205-99-2	22	22	100	Y

**Table C-3**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**  
**0 to 12 inches<sup>a</sup>**

COI <sup>b</sup>	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI <sub>51</sub> (0–12 in)
Benzo[g,h,i]perylene	191-24-2	22	22	100	Y
Benzo[k]fluoranthene	207-08-9	21	19	90	Y
Bis(2-ethylhexyl) phthalate	117-81-7	42	36	86	Y
Butyl benzyl phthalate	85-68-7	22	14	64	Y
Carbazole	86-74-8	41	24	59	Y
Chrysene	218-01-9	22	22	100	Y
Dibenzo[a,h]anthracene	53-70-3	22	16	73	Y
Dibenzofuran	132-64-9	22	3	14	Y
Dimethyl phthalate	131-11-3	22	8	36	Y
Di- <i>n</i> -butyl phthalate	84-74-2	22	7	32	Y
Fluoranthene	206-44-0	22	22	100	Y
Fluorene	86-73-7	41	22	54	Y
Indeno[1,2,3-cd]pyrene	193-39-5	22	22	100	Y
2-Methylnaphthalene	91-57-6	22	12	55	Y
Naphthalene	91-20-3	40	21	53	Y
Phenanthrene	85-01-8	41	40	98	Y
Phenol	108-95-2	42	6	14	Y
Pyrene	129-00-0	22	22	100	Y
<b>Volatile Organic Compounds</b>					
Acetone	67-64-1	21	14	67	Y
Benzene	71-43-2	21	21	100	Y
Bromomethane	74-83-9	21	4	19	Y
2-Butanone	78-93-3	21	17	81	Y
<i>n</i> -Butylbenzene	104-51-8	21	7	33	Y
<i>sec</i> -Butylbenzene	135-98-8	21	3	14	Y
Carbon disulfide	75-15-0	21	20	95	Y
Chlorobenzene	108-90-7	21	2	10	Y
Chloroform	67-66-3	41	3	7	Y
Chloromethane	74-87-3	21	4	19	Y

**Table C-3**  
**Frequency of Detection Screening of COIs for Soil Investigation Area 4 and Adjacent Soil Samples**  
**0 to 12 inches<sup>a</sup>**

COI <sup>b</sup>	CAS Number	Total Number of Samples (N)	Number of Detections (D)	Detection Frequency (%)	COI <sub>SI</sub> (0–12 in)
1,2-Dichlorobenzene	95-50-1	41	0	0	--
1,3-Dichlorobenzene	541-73-1	41	0	0	--
1,4-Dichlorobenzene	106-46-7	41	0	0	--
<i>trans</i> -1,2-Dichloroethene	156-60-5	21	1	5	--
Ethylbenzene	100-41-4	21	18	86	Y
Isopropylbenzene	98-82-8	21	9	43	Y
4-Isopropyltoluene	99-87-6	21	9	43	Y
<i>n</i> -Propylbenzene	103-65-1	21	9	43	Y
Styrene	100-42-5	21	2	10	Y
Toluene	108-88-3	21	19	90	Y
Trichloroethene	79-01-6	21	1	5	--
1,2,4-Trimethylbenzene	95-63-6	21	14	67	Y
1,3,5-Trimethylbenzene	108-67-8	21	8	38	Y
<i>o</i> -Xylene	95-47-6	21	12	57	Y
<i>m,p</i> -Xylenes	179601-23-1	21	21	100	Y

**Notes**

-- not applicable

COI = chemical of interest; detected in greater than 5 percent of soil samples collected in the area for investigation south of I-10 (all depths)

COI<sub>SI</sub> = COI detected in greater than 5 percent of samples collected in the area for investigation south of I-10 at the depth interval of interest for risk evaluation.

a - The 0 to 12 inch depth interval pertains to the hypothetical commercial worker human receptor. Data include 0 to 6 and 6 to 12 inch depth intervals

b - Only chemicals identified as COIs based on frequency of detection soil data within the area for investigation south of I-10 (Table C-1) are included here.

c - Total PCBs is the sum of 43 congeners.

**Table C-4**  
**Human Health Screening Levels for Soils**

Analyte	CAS Number	Screening Level	Basis	Source <sup>a</sup>
<b>Conventionals</b>				
Grain size distribution (percent retained)	--	NA		
Total organic carbon (percent)	--	NA		
<b>Metals (mg/kg-dry weight)</b>				
Aluminum	7429-90-5	9.90E+05	n	USEPA 2012
Arsenic	7440-38-2	1.60E+00	c	USEPA 2012
Barium	7440-39-3	1.90E+05	n	USEPA 2012
Cadmium	7440-43-9	8.00E+02	n	USEPA 2012
Chromium <sup>b</sup>	7440-47-3	1.50E+06	n	USEPA 2012
Cobalt	7440-48-4	3.00E+02	n	USEPA 2012
Copper	7440-50-8	4.10E+04	n	USEPA 2012
Lead	7439-92-1	8.00E+02	n	USEPA 2012
Magnesium	7439-95-4	NV		
Manganese	7439-96-5	2.30E+04	n	USEPA 2012
Mercury	7439-97-6	4.30E+01	n	USEPA 2012
Nickel	7440-02-0	2.00E+04	n	USEPA 2012
Thallium	7440-28-0	1.00E+01	n	USEPA 2012
Vanadium	7440-62-2	5.20E+03	n	USEPA 2012
Zinc	7440-66-6	3.10E+05	n	USEPA 2012
<b>Polychlorinated Biphenyl Congeners (µg/kg-dry weight)</b>				
Total PCBs	1336-36-3	7.40E+02	c	USEPA 2012
<b>Organics</b>				
<b>Dioxins and furans (ng/kg-dry weight)</b>				
TEQ <sub>DF</sub>	1746-01-6	1.80E+01	c	USEPA 2012
<b>Semivolatile Organic Compounds (µg/kg-dry weight)</b>				
Acenaphthene	83-32-9	3.30E+07	n	USEPA 2012
Acenaphthylene	208-96-8	3.72E+07	n	TCEQ 2011
Anthracene	120-12-7	1.70E+08	n	USEPA 2012
Benz[a]anthracene	56-55-3	2.10E+03	c	USEPA 2012
Benzo[a]pyrene	50-32-8	2.10E+02	c	USEPA 2012
Benzo[b]fluoranthene	205-99-2	2.10E+03	c	USEPA 2012
Benzo[ghi]perylene	191-24-2	1.86E+07	n	TCEQ 2011
Benzo[k]fluoranthene	207-08-9	2.10E+04	c	USEPA 2012
Benzoic acid	65-85-0	2.50E+09	n	USEPA 2012
Benzyl alcohol	100-51-6	6.20E+07	n	USEPA 2012
Bis(2-chloroethoxy)methane	111-91-1	1.80E+06	n	USEPA 2012
Bis(2-chloroethyl) ether	111-44-4	1.00E+03	c	USEPA 2012
Bis(2-chloroisopropyl) ether <sup>c</sup>	39638-32-9	2.20E+04	c	USEPA 2012
Bis(2-ethylhexyl) phthalate	117-81-7	1.20E+05	c	USEPA 2012
4-Bromophenyl phenyl ether	101-55-3	1.10E+03	c	TCEQ 2011
Butyl benzyl phthalate	85-68-7	9.10E+05	c	USEPA 2012
Carbazole	86-74-8	9.54E+05	c	TCEQ 2011
4-Chloro-3-methylphenol	59-50-7	6.20E+07	n	USEPA 2012
4-Chloroaniline	106-47-8	8.60E+03	c	USEPA 2012
2-Chloronaphthalene	91-58-7	8.20E+07	n	USEPA 2012
2-Chlorophenol	95-57-8	5.10E+06	n	USEPA 2012
4-Chlorophenyl phenyl ether	7005-72-3	7.99E+02	c	TCEQ 2011
Chrysene	218-01-9	2.10E+05	c	USEPA 2012
Dibenz[a,h]anthracene	53-70-3	2.10E+02	c	USEPA 2012
Dibenzofuran	132-64-9	1.00E+06	n	USEPA 2012

**Table C-4**  
**Human Health Screening Levels for Soils**

Analyte	CAS Number	Screening Level	Basis	Source <sup>a</sup>
3,3'-Dichlorobenzidine	91-94-1	3.80E+03	c	USEPA 2012
2,4-Dichlorophenol	120-83-2	1.80E+06	n	USEPA 2012
Diethyl phthalate	84-66-2	4.90E+08	n	USEPA 2012
Dimethyl phthalate	131-11-3	5.45E+08	n	TCEQ 2011
2,4-Dimethylphenol	105-67-9	1.20E+07	n	USEPA 2012
Di- <i>n</i> -butyl phthalate	84-74-2	6.20E+07	n	USEPA 2012
2,4-Dinitrophenol	51-28-5	1.20E+06	n	USEPA 2012
2,4-Dinitrotoluene	121-14-2	5.50E+03	c	USEPA 2012
2,6-Dinitrotoluene	606-20-2	6.20E+05	n	USEPA 2012
Di- <i>n</i> -octyl phthalate	117-84-0	2.73E+07	n	TCEQ 2011
Fluoranthene	206-44-0	2.20E+07	n	USEPA 2012
Fluorene	86-73-7	2.20E+07	n	USEPA 2012
Hexachlorobenzene	118-74-1	1.10E+03	c	USEPA 2012
Hexachlorocyclopentadiene	77-47-4	3.70E+06	n	USEPA 2012
Hexachloroethane	67-72-1	4.30E+04	c	USEPA 2012
Indeno[1,2,3- <i>cd</i> ]pyrene	193-39-5	2.10E+03	c	USEPA 2012
Isophorone	78-59-1	1.80E+06	c	USEPA 2012
2-Methyl-4,6-dinitrophenol	534-52-1	4.90E+04	n	USEPA 2012
2-Methylnaphthalene	91-57-6	2.20E+06	n	USEPA 2012
2-Methylphenol	95-48-7	3.10E+07	n	USEPA 2012
4-Methylphenol	106-44-5	6.20E+07	n	USEPA 2012
2-Nitroaniline	88-74-4	6.00E+06	n	USEPA 2012
3-Nitroaniline	99-09-2	3.55E+04	n	TCEQ 2011
4-Nitroaniline	100-01-6	8.60E+04	c	USEPA 2012
Nitrobenzene	98-95-3	2.40E+04	c	USEPA 2012
2-Nitrophenol	88-75-5	1.36E+06	n	TCEQ 2011
4-Nitrophenol	100-02-7	1.36E+06	n	TCEQ 2011
<i>N</i> -Nitrosodi- <i>n</i> -propylamine	621-64-7	2.50E+02	c	USEPA 2012
<i>N</i> -Nitrosodiphenylamine	86-30-6	3.50E+05	c	USEPA 2012
Pentachlorophenol	87-86-5	2.70E+03	c	USEPA 2012
Phenanthrene	85-01-8	1.86E+07	n	TCEQ 2011
Phenol	108-95-2	1.80E+08	n	USEPA 2012
Pyrene	129-00-0	1.70E+07	n	USEPA 2012
2,4,5-Trichlorophenol	95-95-4	6.20E+07	n	USEPA 2012
2,4,6-Trichlorophenol	88-06-2	1.60E+05	c	USEPA 2012
Volatile Organic Compounds (µg/kg-dry weight)				
Acetone	67-64-1	6.30E+08	n	USEPA 2012
Benzene	71-43-2	5.40E+03	c	USEPA 2012
Bromobenzene	108-86-1	1.80E+06	n	USEPA 2012
Bromochloromethane	74-97-5	6.80E+05	n	USEPA 2012
Bromodichloromethane	75-27-4	1.40E+03	c	USEPA 2012
Bromoform	75-25-2	2.20E+05	c	USEPA 2012
Bromomethane	74-83-9	3.20E+04	n	USEPA 2012
2-Butanone	78-93-3	2.00E+08	n	USEPA 2012
<i>n</i> -Butylbenzene	104-51-8	5.10E+07	n	USEPA 2012
<i>sec</i> -Butylbenzene	135-98-8	4.09E+07	n	TCEQ 2011
<i>tert</i> -Butylbenzene	98-06-6	4.09E+07	n	TCEQ 2011
Carbon disulfide	75-15-0	3.70E+06	n	USEPA 2012
Carbon tetrachloride	56-23-5	3.00E+03	c	USEPA 2012
Chlorobenzene	108-90-7	1.40E+06	n	USEPA 2012
Chloroethane	75-00-3	6.10E+07	n	USEPA 2012

**Table C-4**  
**Human Health Screening Levels for Soils**

Analyte	CAS Number	Screening Level	Basis	Source <sup>a</sup>
Chloroform	67-66-3	1.50E+03	c	USEPA 2012
Chloromethane	74-87-3	5.00E+05	n	USEPA 2012
2-Chlorotoluene	95-49-8	2.00E+07	n	USEPA 2012
4-Chlorotoluene	106-43-4	2.00E+07	n	USEPA 2012
1,2-Dibromo-3-chloropropane	96-12-8	6.90E+01	c	USEPA 2012
Dibromochloromethane	124-48-1	3.30E+03	c	USEPA 2012
1,2-Dibromoethane	106-93-4	1.70E+02	c	USEPA 2012
Dibromomethane	74-95-3	1.10E+05	n	USEPA 2012
1,2-Dichlorobenzene	95-50-1	9.80E+06	n	USEPA 2012
1,3-Dichlorobenzene	541-73-1	8.82E+04	n	TCEQ 2011
1,4-Dichlorobenzene	106-46-7	1.20E+04	c	USEPA 2012
Dichlorodifluoromethane	75-71-8	4.00E+05	n	USEPA 2012
1,1-Dichloroethane	75-34-3	1.70E+04	c	USEPA 2012
1,2-Dichloroethane	107-06-2	2.20E+03	c	USEPA 2012
1,1-Dichloroethene	75-35-4	1.10E+06	n	USEPA 2012
cis -1,2-Dichloroethene	156-59-2	2.00E+06	n	USEPA 2012
trans -1,2-Dichloroethene	156-60-5	6.90E+05	n	USEPA 2012
1,2-Dichloropropane	78-87-5	4.70E+03	c	USEPA 2012
1,3-Dichloropropane	142-28-9	2.00E+07	n	USEPA 2012
2,2-Dichloropropane	594-20-7	4.42E+04	n	TCEQ 2011
1,1-Dichloropropene	563-58-6	6.09E+04	c	TCEQ 2011
cis -1,3-Dichloropropene	10061-01-5	5.30E+04	c	TCEQ 2011
trans -1,3-Dichloropropene	10061-02-6	6.09E+04	c	TCEQ 2011
Ethylbenzene	100-41-4	2.70E+04	c	USEPA 2012
Hexachlorobutadiene	87-68-3	2.20E+04	c	USEPA 2012
2-Hexanone	591-78-6	1.40E+06	n	USEPA 2012
Isopropylbenzene	98-82-8	1.10E+07	n	USEPA 2012
4-Isopropyltoluene	99-87-6	1.02E+08	n	TCEQ 2011
4-Methyl-2-pentanone	108-10-1	5.30E+07	n	USEPA 2012
Methylene chloride	75-09-2	9.60E+05	c	USEPA 2012
Naphthalene	91-20-3	1.80E+04	c	USEPA 2012
n -Propylbenzene	103-65-1	2.10E+07	n	USEPA 2012
Styrene	100-42-5	3.60E+07	n	USEPA 2012
1,1,1,2-Tetrachloroethane	630-20-6	9.30E+03	c	USEPA 2012
1,1,2,2-Tetrachloroethane	79-34-5	2.80E+03	c	USEPA 2012
Tetrachloroethene	127-18-4	1.10E+05	c	USEPA 2012
Toluene	108-88-3	4.50E+07	n	USEPA 2012
1,2,3-Trichlorobenzene	87-61-6	4.90E+05	n	USEPA 2012
1,2,4-Trichlorobenzene	120-82-1	9.90E+04	c	USEPA 2012
1,1,2-Trichloroethane	79-00-5	5.30E+03	c	USEPA 2012
1,1,1-Trichloroethane	71-55-6	3.80E+07	n	USEPA 2012
Trichloroethene	79-01-6	6.40E+03	c	USEPA 2012
Trichlorofluoromethane	75-69-4	3.40E+06	n	USEPA 2012
1,2,3-Trichloropropane	96-18-4	9.50E+01	c	USEPA 2012
1,2,4-Trimethylbenzene	95-63-6	2.60E+05	n	USEPA 2012
1,3,5-Trimethylbenzene	108-67-8	1.00E+07	n	USEPA 2012

**Table C-4**  
**Human Health Screening Levels for Soils**

Analyte	CAS Number	Screening Level	Basis	Source <sup>a</sup>
Vinyl chloride	75-01-4	1.70E+03	c	USEPA 2012
<i>o</i> -Xylene	95-47-6	3.00E+06	n	USEPA 2012
<i>m,p</i> -Xylenes <sup>d</sup>	179601-23-1	2.70E+06	n	USEPA 2012

**Notes**

-- = information is not available

c = screening level is based on a carcinogenic endpoint

n = screening level is based on a non-carcinogenic endpoint

NA = not applicable

NV = no value available

TCEQ = Texas Commission on Environmental Quality

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

USEPA = United States Environmental Protection Agency

a - Screening values were selected using the following tiered approach:

Tier 1: USEPA 2012. USEPA Risk-Based Screening Levels for Industrial Soil. Last updated May 2012 and available at:

[http://www.epa.gov/reg3hwmd/risk/human/rb-concentration\\_table/Generic\\_Tables/index.htm](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm). Accessed May 15, 2012.

Tier 2: TCEQ 2011. TCEQ Tier 1 Commercial/Industrial Protective Concentration Levels for 30 acre source. Table 2. Last

updated May 2011 and available at: <http://www.tceq.state.tx.us/remediation/trrp/trrppcls.html>. Accessed May 16, 2012.

b - The chromium (VI) screening level is lower than the chromium (III) level; however, speciation of chromium will not be performed so the screening value for chromium (VI) was not included. The value shown is for chromium (III) because no screening value was available for total chromium.

c - The value shown is for bis(2-chloro-1-methylethyl)ether (CASRN: 108-60-1) since no screening value was available for bis(2-chloroisopropyl) ether.

d - Screening value is for xylenes.

**Table C-5**  
**Human Health COPC Screening for Soil Investigation Area 4 and Adjacent Soil Samples**

COI <sup>a</sup>	CAS Number	Screening Level	Surface and Shallow Subsurface Soils (0–12 Inches) <sup>b</sup>			Surface Soils (0–6 Inches) <sup>c</sup>		
			Detection Frequency (%)	Maximum Detected Concentration	Exceed Screening Level?	Detection Frequency (%)	Maximum Detected Concentration	Exceed Screening Level?
Metals (mg/kg-dry weight)								
Aluminum	7429-90-5	9.90E+05	100.0	11900	No	100.0	11400	No
Arsenic	7440-38-2	1.60E+00	100.0	390	Yes	100.0	390	Yes
Barium	7440-39-3	1.90E+05	100.0	840	No	100.0	840	No
Cadmium	7440-43-9	8.00E+02	97.7	6.96	No	100.0	6.96	No
Chromium	7440-47-3	1.50E+06	100.0	215	No	100.0	86.3	No
Cobalt	7440-48-4	3.00E+02	100.0	67.3	No	100.0	67.3	No
Copper	7440-50-8	4.10E+04	100.0	1990	No	100.0	1990	No
Lead	7439-92-1	8.00E+02	100.0	896	Yes	100.0	896	Yes
Magnesium	7439-95-4	NV	100.0	14900	see footnote d	100.0	14900	see footnote d
Manganese	7439-96-5	2.30E+04	100.0	10500	No	100.0	10500	No
Mercury	7439-97-6	4.30E+01	100.0	0.628	No	100.0	0.628	No
Nickel	7440-02-0	2.00E+04	100.0	91.2	No	100.0	71.1	No
Thallium	7440-28-0	1.00E+01	46.5	9.8	No	54.5	9.8	No
Vanadium	7440-62-2	5.20E+03	100.0	110	No	100.0	110	No
Zinc	7440-66-6	3.10E+05	100.0	8050	No	100.0	8050	No
Polychlorinated Biphenyl Congeners (µg/kg-dry weight)								
Total PCBs <sup>e,f</sup>	1336-36-3	7.40E+02						
Total PCB Congeners		7.40E+02	100.0	347	No	100.0	276	No
Organics								
Dioxins and furans (ng/kg-dry weight)								
TEQ <sub>DF</sub> mammals		1.80E+01	100.0	38.8	Yes	100.0	36.9	Yes
Semivolatile Organic Compounds (µg/kg-dry weight)								
Acenaphthene	83-32-9	3.30E+07	58.5	88	No	66.7	51	No
Acenaphthylene	208-96-8	3.72E+07	50.0	360	No	45.5	58	No
Anthracene	120-12-7	1.70E+08	68.2	820	No	81.8	92	No
Benz[a]anthracene	56-55-3	2.10E+03	95.5	460	No	100.0	460	No
Benzo[a]pyrene	50-32-8	2.10E+02	100.0	620	Yes	100.0	540	Yes
Benzo[b]fluoranthene	205-99-2	2.10E+03	100.0	1100	No	100.0	720	No
Benzo[ghi]perylene	191-24-2	1.86E+07	100.0	890	No	100.0	370	No
Benzo[k]fluoranthene	207-08-9	2.10E+04	90.5	340	No	100.0	250	No
Bis(2-ethylhexyl) phthalate	117-81-7	1.20E+05	85.7	3500	No	95.2	3500	No
Butyl benzyl phthalate	85-68-7	9.10E+05	63.6	910	No	63.6	860	No
Carbazole	86-74-8	9.54E+05	58.5	240	No	61.9	48	No

**Table C-5**  
**Human Health COPC Screening for Soil Investigation Area 4 and Adjacent Soil Samples**

COI <sub>SL</sub> <sup>a</sup>	CAS Number	Screening Level	Surface and Shallow Subsurface Soils (0–12 Inches) <sup>b</sup>			Surface Soils (0–6 inches) <sup>c</sup>		
			Detection Frequency (%)	Maximum Detected Concentration	Exceed Screening Level?	Detection Frequency (%)	Maximum Detected Concentration	Exceed Screening Level?
Chrysene	218-01-9	2.10E+05	100.0	680	No	100.0	570	No
Dibenz[a,h]anthracene	53-70-3	2.10E+02	72.7	210	No	90.9	85	No
Dibenzofuran	132-64-9	1.00E+06	13.6	37	No	9.1	22	No
Dimethyl phthalate	131-11-3	5.45E+08	36.4	230	No	45.5	200	No
Di-n-butyl phthalate	84-74-2	6.20E+07	31.8	130	No	36.4	130	No
Fluoranthene	206-44-0	2.20E+07	100.0	870	No	100.0	720	No
Fluorene	86-73-7	2.20E+07	53.7	46	No	61.9	46	No
Indeno[1,2,3-cd]pyrene	193-39-5	2.10E+03	100.0	880	No	100.0	390	No
2-Methylnaphthalene	91-57-6	2.20E+06	54.5	87	No	45.5	73	No
Naphthalene	91-20-3	1.80E+04	52.5	50	No	55.0	30	No
Phenanthrene	85-01-8	1.86E+07	97.6	620	No	100.0	450	No
Phenol	108-95-2	1.80E+08	14.3	6.4	No	14.3	6.4	No
Pyrene	129-00-0	1.70E+07	100.0	820	No	100.0	730	No
Volatile Organic Compounds (µg/kg-dry weight)								
Acetone	67-64-1	6.30E+08	66.7	330	No	70.0	240	No
Benzene	71-43-2	5.40E+03	100.0	73	No	100.0	17	No
Bromomethane	74-83-9	3.20E+04	19.0	2.5	No	30.0	2.5	No
2-Butanone	78-93-3	2.00E+08	81.0	50	No	80.0	39	No
n-Butylbenzene	104-51-8	5.10E+07	33.3	0.96	No	10.0	0.32	No
sec-Butylbenzene	135-98-8	4.09E+07	14.3	0.33	No	0.0	--	--
Carbon disulfide	75-15-0	3.70E+06	95.2	41	No	90.0	20	No
Chlorobenzene	108-90-7	1.40E+06	9.5	0.21	No	10.0	0.17	No
Chloroform	67-66-3	1.50E+03	7.3	3.5	No	5.0	--	--
Chloromethane	74-87-3	5.00E+05	19.0	5.2	No	10.0	4.1	No
trans-1,2-Dichloroethene	156-60-5	6.90E+05	4.8	--	--	10.0	0.44	No
Ethylbenzene	100-41-4	2.70E+04	85.7	25	No	80.0	4	No
Isopropylbenzene	98-82-8	1.10E+07	42.9	1.3	No	30.0	0.32	No
4-Isopropyltoluene	99-87-6	1.02E+08	42.9	0.73	No	20.0	0.19	No
n-Propylbenzene	103-65-1	2.10E+07	42.9	2.5	No	30.0	0.61	No
Styrene	100-42-5	3.60E+07	9.5	1.2	No	0.0	--	--
Toluene	108-88-3	4.50E+07	90.5	110	No	80.0	17	No
1,2,4-Trimethylbenzene	95-63-6	2.60E+05	66.7	3.8	No	60.0	1	No

**Table C-5**  
**Human Health COPC Screening for Soil Investigation Area 4 and Adjacent Soil Samples**

COI <sub>SI</sub> <sup>a</sup>	CAS Number	Screening Level	Surface and Shallow Subsurface Soils (0–12 Inches) <sup>b</sup>			Surface Soils (0–6 Inches) <sup>c</sup>		
			Detection Frequency (%)	Maximum Detected Concentration	Exceed Screening Level?	Detection Frequency (%)	Maximum Detected Concentration	Exceed Screening Level?
1,3,5-Trimethylbenzene	108-67-8	1.00E+07	38.1	1.3	No	30.0	0.46	No
<i>o</i> -Xylene	95-47-6	3.00E+06	57.1	11	No	50.0	1.9	No
<i>m,p</i> -Xylenes	179601-23-1	2.70E+06	100.0	25	No	100.0	4.1	No

**Notes**

-- = not applicable

COI<sub>SI</sub> = COI detected in greater than 5 percent of samples collected in the area for investigation south of I-10 at the depth interval of interest for risk evaluation.

COPC = chemical of potential concern

NV = no value

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furan

a - Only chemicals identified as COI<sub>SI</sub>s based on frequency of detection in all southern impoundment soil data (Tables C-2 and C-3) are included here.

b - The 0 to 12-inch depth interval pertains to the Commercial Worker human receptor.

c - The 0 to 6-inch depth interval pertains to the Trespasser human receptor.

d - Magnesium is considered an essential nutrient; therefore, according to USEPA (1989), it is not considered further in the risk assessment process.

e - Total PCBs is the sum of 43 congeners.

f - Non-detects were set to one-half the detection limit.

**Table C-6**  
**Chemicals of Potential Concern for Human Health for Soil**  
**Investigation Area 4 and Adjacent Soil Samples**

<b>COPC<sub>HS</sub></b>
<b>Dioxins and Furans</b>
Dioxins and Furans (TEQ <sub>DF</sub> )
<b>Metals</b>
Arsenic
<b>Semivolatile Organic Compounds</b>
Benzo(a)pyrene

**Notes**

COPC<sub>HS</sub> = chemicals of potential concern for human health

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

**APPENDIX D**  
**SUPPLEMENTAL TOXICOLOGICAL AND**  
**CHEMICAL-SPECIFIC PARAMETERS**

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# APPENDIX D

## SUPPLEMENTAL TOXICOLOGICAL AND CHEMICAL-SPECIFIC PARAMETERS

### SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

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#### **Prepared for**

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## List of Acronyms and Abbreviations

Abbreviation	Definition
ADAF	age-dependent adjustment factor
ATSDR	Agency for Toxic Substances and Disease Registry
BaP	benzo(a)pyrene
BHHRA	baseline human health risk assessment
CalEPA	California Environmental Protection Agency
COPC	chemical of potential concern
COPC <sub>H</sub>	chemical of potential concern for human health
CSF	cancer slope factor
EAM	Exposure Assessment Memorandum
HEAST	Health Effects Assessment Summary Tables
I-10	Interstate Highway 10
IRIS	Integrated Risk Information System
MRL	Minimal risk level
OEHHA	Office of Environmental Health Hazard Assessment
PPRTV	Provisional Peer Reviewed Toxicity Value
RfD	reference dose
Site	San Jacinto River Waste Pits site in Harris County, Texas
SJRWP	San Jacinto River Waste Pits
TESM	Toxicological and Epidemiological Studies Memorandum
USEPA	U.S. Environmental Protection Agency

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## 1 INTRODUCTION

The Toxicological and Epidemiological Studies Memorandum (TESM) (Integral 2012a) and Exposure Assessment Memorandum (EAM) (Integral 2012b) stated that any chemicals of potential concern from human health (COPCHS) in addition to those presented within those memoranda, will be addressed in an appendix to the baseline human health risk assessment (BHHRA) report. The purpose of this appendix is to establish toxicological criteria and other chemical-specific parameters for those additional COPCHS. As discussed in Appendix C, the screening analysis for the area of investigation on the peninsula south of Interstate Highway 10 (I-10) identified dioxins and furans, arsenic, and benzo(a)pyrene (BaP) as the COPCHS to be evaluated for this area. Of these COPCHS, BaP is the only COPCH that was not addressed in the TESM and is addressed in this appendix.

## 2 APPROACH

### 2.1 Selection of Toxicological Criteria

The approach used to select toxicological criteria was presented in the TESM and is briefly discussed here. Toxicological criteria are numerical expressions of chemical dose and response. In a BHHRA, toxicological criteria for each of the COPCHS are used along with estimates of exposures to develop estimates of potential risks and/or hazards. Some COPCHS are considered to cause both cancer and noncancer health effects and, therefore, can have toxicological criteria for both endpoints.

To assess the potential carcinogenic health effects from oral and dermal exposures, U.S. Environmental Protection Agency (USEPA) typically has developed cancer slope factors (CSFs), which are considered upper-bound estimates of the carcinogenic potency of chemicals. To evaluate potential noncancer health effects, the potential hazard is evaluated by comparing the estimated daily intake with a reference dose (RfD) or with another estimate of a safe daily dose. For long-term exposures, a chronic RfD is applied and is defined as a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA 1989). Subchronic RfDs represent average daily exposure levels at which no adverse health effects are expected to occur with subchronic exposures of 7 years or less, as would be the case for the hypothetical trespasser scenario to be evaluated.

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USEPA (2003) has outlined a hierarchy of sources to be considered in selecting toxicological criteria. In accordance with USEPA's hierarchy, the toxicological sources considered, in order of preference, were:

- Tier 1: USEPA's IRIS<sup>1</sup>
- Tier 2: USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) from the National Center for Environmental Assessment/Superfund Health Risk Technical Support Center<sup>2</sup>
- Tier 3: Other USEPA and non-USEPA sources, such as the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs)<sup>3</sup>, USEPA's Health Effects Assessment Summary Tables (HEAST; USEPA 1997), California EPA (CalEPA) values,<sup>4</sup> and other sources that are current, publicly available, and have been peer reviewed.

## 2.2 Selection of Other Chemical Specific Parameters

Other chemical-specific parameters including relative bioavailability and dermal absorption factors were selected considering peer reviewed literature and USEPA guidance.

## 3 TOXICOLOGICAL CRITERIA

This section presents the specific toxicological criteria to be used to evaluate the toxicity of BaP. BaP is classified as a B2 carcinogen (probable human carcinogen) based on sufficient evidence of carcinogenicity in animals (USEPA 2012). No toxicity criterion for noncancer health effects is available for this chemical from any of the Tier 1, 2, and 3 sources listed above. Toxicological criteria for the other two COPCHs for the area of investigation on the peninsula south of I-10 (arsenic, dioxins and furans) were presented in the TESM (Integral 2012a).

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<sup>1</sup> Available at: <http://www.epa.gov/ncea/iris/>.

<sup>2</sup> Values available at: <http://hhpprtv.ornl.gov/>

<sup>3</sup> Available at: <http://www.atsdr.cdc.gov/mrls/index.asp>

<sup>4</sup> Available at: [http://www.oehha.ca.gov/air/hot\\_spots/tsd052909.html](http://www.oehha.ca.gov/air/hot_spots/tsd052909.html)

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Human carcinogenicity data for BaP are inadequate, but multiple animal studies in numerous species have demonstrated carcinogenicity following BaP administration via a number of exposure routes. USEPA's Tier 1 CSF for BaP, which has been adopted for use in the BHHRA, is  $7.3 \text{ (mg/kg/day)}^{-1}$  (USEPA 2012). This CSF is based on a geometric mean of four slope factors, ranging from 4.5 to  $11.7 \text{ (mg/kg/day)}^{-1}$ . The four slope factors are based on data from two rodent studies, Neal and Rigdon (1967) and Brune et al. (1981). These studies are discussed below.

Neal and Rigdon (1967) administered BaP in the diet of male and female mice at concentrations of 0, 1, 10, 20, 30, 40, 45, 50, 100, and 250 ppm. Forestomach tumors were reported in the 20-, 30-, 40-, 45-, 50-, 100-, and 250 ppm dose groups. No forestomach tumors were reported in the other dose groups. Brune et al. (1981) administered BaP in the diet of male and female Sprague-Dawley rats at a concentration of 0.15 mg/kg either every ninth day or five times per week for a year, resulting in doses of 6 and 39 mg/kg/year, respectively. Tumors of the forestomach, esophagus and larynx were reported.

Three different low-dose extrapolation models of the Neal and Rigdon (1967) data were used to estimate three of the four slope factors (4.5, 5.9, and 9.0 per mg/kg/day). The linearized multistage model was used for the combined tumor incidence data from Brune et al. (1981) to estimate the fourth slope factor (11.7 per mg/kg/day). According to USEPA (2012), "there are precedents for using multiple data sets from different studies using more than one sex, strain and species; the use of the geometric mean of four slope factors is preferred because it makes use of more of the available data."

BaP also has been shown to cause genotoxic effects in both prokaryotic and mammalian cell assay tests, including forward and reverse mutation assays, chromosomal effects assays and cell transformation assays (USEPA 2012). Because of the positive results in the genotoxicity assays, BaP is considered a carcinogen with a mutagenic mode of action (USEPA 2005). USPEA specifies that for those chemicals with a possible mutagenic mode of action, cancer susceptibility from early life exposures should be considered. The *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (USEPA 2005) addresses cancer risks associated with early-life exposures and provides guidance on adjusting cancer potency estimates for carcinogens that act through a mutagenic mode of action. When no

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chemical-specific data are available to evaluate cancer susceptibility from early-life exposure to a carcinogen with a mutagenic mode of action, USEPA (2005) recommends applying age-dependent adjustment factors (ADAFs) as appropriate to develop risk estimates. To evaluate risk during the first 2 years of life, an ADAF of 10 is recommended; for ages 2 to <16 years, an ADAF of 3; and for ages 16 years and older, an ADAF of 1. Although BaP is a COPCH and is considered to have a mutagenic mode of action, early-life susceptibility is not relevant for the hypothetical trespasser or commercial worker because the age of both receptors is 16 years and older.

#### **4 OTHER CHEMICAL-SPECIFIC CRITERIA**

As outlined in the EAM (Integral 2012b), exposure estimates rely on both scenario-specific exposure assumptions and chemical-specific factors. The latter includes oral bioavailability and dermal absorption factors. For BaP, the oral bioavailability was assumed to be 1.0. For the dermal absorption factor, which represents the proportion of chemical that is absorbed across the skin from the soil once contacted, a value of 0.13 (13 percent), was adopted from USEPA's (2004) Dermal Guidance.

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**APPENDIX E**  
**EXPOSURE POINT CONCENTRATIONS**  
**FOR BASELINE AND BACKGROUND**  
**EXPOSURE ESTIMATES**

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**Table E-1**  
**Exposure Point Concentrations for Sediment, Baseline Conditions**

Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Beach Area A	<b>Dioxins and Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	5	100	--	--	normal	ucl.t	0.310	0.456	0.495
	TEQ <sub>DF</sub> (ND = DL0)	ng/kg	5	100	--	--	normal	ucl.t	0.198	0.339	0.373
	<b>Metals</b>										
	Arsenic	mg/kg	5	100	--	--	normal	ucl.t	0.2	0.3	0.4
	Cadmium	mg/kg	5	0	0.2	0.2	all below DL	max	0.1	0.1	0.1
	Chromium	mg/kg	5	80	0.37	0.37	normal	ucl.t	0.6	0.84	0.83
	Copper	mg/kg	5	40	0.7	0.7	lognormal	ucl.cheb.log	0.812	4.26	3.5
	Mercury	mg/kg	5	100	--	--	normal	ucl.t	0.0059	0.0104	0.014
	Nickel	mg/kg	5	20	0.5	0.6	normal	ucl.t	0.315	0.377	0.425
	Zinc	mg/kg	5	100	--	--	lognormal	ucl.cheb.log	3.35	8.61	9
	<b>Polychlorinated Biphenyls</b>										
	Sum of Aroclors (ND = 1/2DL)	--	NA	--	--	--	--	--	--	--	--
	Sum of Aroclors (ND = DL0)	--	NA	--	--	--	--	--	--	--	--
	TEQ <sub>p</sub> (ND = 1/2DL)	--	NA	--	--	--	--	--	--	--	--
	TEQ <sub>p</sub> (ND = DL0)	--	NA	--	--	--	--	--	--	--	--
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	5	0	19	19	all below DL	max	9.5	9.5	9.5
Beach Area B/C	<b>Dioxins and Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	4.09	6.36	10.9
	TEQ <sub>DF</sub> (ND = DL0)	ng/kg	10	100	--	--	normal	ucl.t	3.77	6.12	10.7
	<b>Metals</b>										
	Arsenic	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	1.59	2.52	3.63
	Cadmium	mg/kg	10	40	0.04	0.05	unknown	ucl.proucl.np	0.082	0.214	0.27
	Chromium	mg/kg	10	100	--	--	unknown	ucl.proucl.np	8.1	21.7	35.7
	Copper	mg/kg	10	100	--	--	normal	ucl.t	5.7	7	9.3
	Mercury	mg/kg	10	80	0.009	0.009	normal	ucl.t	0.01	0.02	0.02
	Nickel	mg/kg	10	100	--	--	unknown	ucl.proucl.np	5.17	8.8	12.5
	Zinc	mg/kg	10	100	--	--	unknown	ucl.proucl.np	24.7	48.1	55.4
	<b>Polychlorinated Biphenyls</b>										
	Sum of Aroclors (ND = 1/2DL)	--	NA	--	--	--	--	--	--	--	--
	Sum of Aroclors (ND = DL0)	--	NA	--	--	--	--	--	--	--	--
	TEQ <sub>p</sub> (ND = 1/2DL)	--	NA	--	--	--	--	--	--	--	--
	TEQ <sub>p</sub> (ND = DL0)	--	NA	--	--	--	--	--	--	--	--
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	10	50	19	19	lognormal	ucl.cheb.log	23.7	93.3	120

**Table E-1**  
**Exposure Point Concentrations for Sediment, Baseline Conditions**

Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Beach Area D	<b>Dioxins/Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	7	100	--	--	normal	ucl.t	1.42	2.12	2.90
	TEQ <sub>DF</sub> (ND = DL0)	ng/kg	7	100	--	--	normal	ucl.t	1.30	2.00	2.80
	<b>Metals</b>										
	Arsenic	mg/kg	7	100	--	--	normal	ucl.t	1.93	2.43	2.95
	Cadmium	mg/kg	7	100	--	--	normal	ucl.t	0.334	0.431	0.58
	Chromium	mg/kg	7	100	--	--	unknown	ucl.proucl.np	5.98	11.3	13.1
	Copper	mg/kg	7	100	--	--	normal	ucl.t	5.84	7.88	10.4
	Mercury	mg/kg	7	85.7	0.002	0.002	normal	ucl.t	0.02	0.04	0.05
	Nickel	mg/kg	7	100	--	--	normal	ucl.t	5.41	6.5	6.82
	Zinc	mg/kg	7	100	--	--	normal	ucl.t	29.9	45.8	66.4
	<b>Polychlorinated Biphenyls</b>										
	Sum of Aroclors (ND = 1/2DL)	--	NA	--	--	--	--	--	--	--	--
	Sum of Aroclors (ND = DL0)	--	NA	--	--	--	--	--	--	--	--
	TEQ <sub>p</sub> (ND = 1/2DL)	--	NA	--	--	--	--	--	--	--	--
	TEQ <sub>p</sub> (ND = DL0)	--	NA	--	--	--	--	--	--	--	--
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	7	71.4	19	19	normal	ucl.t	31.9	49.2	73
Beach Area E	<b>Dioxins and Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	17	100	--	--	lognormal	ucl.cheb.log	910	47000	13000
	TEQ <sub>DF</sub> (ND = DL0)	ng/kg	17	100	--	--	lognormal	ucl.cheb.log	880	46000	13000
	<b>Metals</b>										
	Arsenic	mg/kg	13	100	--	--	normal	ucl.t	1.7	1.9	2.35
	Cadmium	mg/kg	13	84.6	0.04	0.05	lognormal	ucl.cheb.log	0.299	2.73	1.6
	Chromium	mg/kg	13	100	--	--	lognormal	ucl.cheb.log	8.03	16	23.6
	Copper	mg/kg	13	100	--	--	lognormal	ucl.cheb.log	16.1	57.5	65.6
	Mercury	mg/kg	13	100	--	--	lognormal	ucl.cheb.log	0.2	4	2
	Nickel	mg/kg	13	100	--	--	normal	ucl.t	7.09	9.33	14.4
	Zinc	mg/kg	13	100	--	--	lognormal	ucl.cheb.log	64.7	222	228
	<b>Polychlorinated Biphenyls</b>										
	Sum of Aroclors (ND = 1/2DL) <sup>e</sup>	µg/kg	4	0	130	2800	all below DL	max of A 1254	560	560	1400
	Sum of Aroclors (ND = DL0)	µg/kg	4	0	130	2800	all below DL	max	0	0	0

**Table E-1**  
**Exposure Point Concentrations for Sediment, Baseline Conditions**

Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
	TEQ <sub>p</sub> (ND = 1/2DL)	ng/kg	4	100	--	--	normal	ucl.t	2.99	4.63	4.5
	TEQ <sub>p</sub> (ND = DL0)	ng/kg	4	100	--	--	normal	ucl.t	1.61	2.35	2.43
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	13	100	--	--	lognormal	ucl.cheb.log	212	693	1600

**Reference**

USEPA, 2010. ProUCL Version 4.1.00 technical guide. EPA/600/R-07/041. May 2010.

**Notes**

-- = not applicable

COPC<sub>H</sub> = chemical of potential concern for human health

DL = detection limit

max = the maximum value was selected as the UCL in instances where the detection frequency was 0

NA = not available, no samples were analyzed for this analyte at this exposure unit

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DL0 = Nondetects set at zero

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>p</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

UCL = upper confidence limit on the mean

ucl.t = UCL for normally distributed data, calculated based on the T statistic

ucl.cheb.log = UCL for lognormally distributed data, using a chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

a - All concentrations are on a dry weight basis unless the units indicate otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the central tendency exposure point concentration.

c - In line with the data treatment rules defined for this project nondetected values were treated as one-half the DL in determining the mean and maximum concentrations. Exceptions are noted with DL0. In these cases nondetected concentrations were treated as 0.

d - The lower of the UCL and maximum will be used as the reasonable maximum exposure point concentration.

e - Due to matrix interferences that resulted in elevated detection limits, analytical results for 1254 were used. See main text for further discussion.

**Table E-2**  
**Exposure Point Concentrations for Tissue, Baseline Conditions**

Tissue Type	Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Hardhead Catfish Fillet	FCA 1	Dioxins and Furans										
		TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	2.94	3.92	5.45
		TEQ <sub>DF</sub> (ND = DLO)	ng/kg	10	100	--	--	normal	ucl.t	2.88	3.86	5.32
		Metals										
		Arsenic	mg/kg	10	100	--	--	normal	ucl.t	0.484	0.564	0.698
		Cadmium	mg/kg	10	20	0.001	0.0011	unknown	ucl.proucl.np	0.000925	0.00238	0.0039
		Chromium	mg/kg	10	50	0.02	0.02	unknown	ucl.proucl.np	0.033	0.0926	0.14
		Copper	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	0.344	0.509	0.612
		Mercury	mg/kg	10	100	--	--	normal	ucl.t	0.159	0.19	0.266
		Nickel	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	0.027	0.0612	0.076
		Zinc	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	19.8	29.4	39.7
		Polychlorinated Biphenyls										
		Sum of 43 PCB Congeners (ND = 1/2DL)	ng/kg	12	100	--	--	normal	ucl.t	84800	104000	156000
		Sum of 43 PCB Congeners (ND = DLO)	ng/kg	12	100	--	--	normal	ucl.t	84800	104000	156000
		TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	12	100	--	--	normal	ucl.t	1.38	1.67	2.27
		TEQ <sub>P</sub> (ND = DLO)	ng/kg	12	100	--	--	normal	ucl.t	1.04	1.43	2.17
		Semivolatile Organic Compounds										
		Bis(2-ethylhexyl)phthalate	µg/kg	10	0	210	210	all below DL	max	105	105	105
	FCA 2/3	Dioxins and Furans										
		TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	20	100	--	--	normal	ucl.t	3.58	4.06	5.85
		TEQ <sub>DF</sub> (ND = DLO)	ng/kg	20	100	--	--	normal	ucl.t	3.51	3.99	5.84
		Metals										
		Arsenic	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	0.389	0.665	1.42
		Cadmium	mg/kg	20	10	0.001	0.0013	unknown	ucl.proucl.np	0.000678	0.00103	0.002
		Chromium <sup>e</sup>	mg/kg	20	40	0.02	0.02	unknown	ucl.proucl.np	0.027	0.0347	0.08
		Copper	mg/kg	20	100	--	--	normal	ucl.t	0.265	0.28	0.381
		Mercury	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	0.0908	0.143	0.264
		Nickel	mg/kg	20	95	0.013	0.013	lognormal	ucl.cheb.log	0.0186	0.032	0.064
		Zinc	mg/kg	20	100	--	--	normal	ucl.t	16.4	18	26.2
		Polychlorinated Biphenyls										
		Sum of 43 PCB Congeners (ND = 1/2DL)	ng/kg	20	100	--	--	normal	ucl.t	83000	94200	129000
		Sum of 43 PCB Congeners (ND = DLO)	ng/kg	20	100	--	--	normal	ucl.t	83000	94200	129000
		TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	20	100	--	--	normal	ucl.t	1.32	1.57	2.79
		TEQ <sub>P</sub> (ND = DLO)	ng/kg	20	100	--	--	lognormal	ucl.cheb.log	0.696	2.38	2.7
		Semivolatile Organic Compounds										
		Bis(2-ethylhexyl)phthalate	µg/kg	20	0	210	210	all below DL	max	105	105	105

**Table E-2**  
**Exposure Point Concentrations for Tissue, Baseline Conditions**

Tissue Type	Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Edible Clam	FCA 1/3	Dioxins and Furans										
		TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	1.27	1.65	2.19
		TEQ <sub>DF</sub> (ND = DL0)	ng/kg	10	100	--	--	normal	ucl.t	1.09	1.51	2.12
		Metals										
		Arsenic	mg/kg	10	100	--	--	normal	ucl.t	0.491	0.523	0.604
		Cadmium	mg/kg	10	100	--	--	normal	ucl.t	0.0253	0.0268	0.0297
		Chromium	mg/kg	10	100	--	--	normal	ucl.t	0.169	0.201	0.29
		Copper	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	2.29	3.37	3.37
		Mercury	mg/kg	10	100	--	--	normal	ucl.t	0.0111	0.0128	0.0178
		Nickel	mg/kg	10	100	--	--	normal	ucl.t	1.39	1.58	1.87
		Zinc	mg/kg	10	100	--	--	normal	ucl.t	9.74	10.6	12.7
		Polychlorinated Biphenyls										
		Sum of 43 PCB Congeners (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	19300	21700	26900
		Sum of 43 PCB Congeners (ND = DL0)	ng/kg	10	100	--	--	normal	ucl.t	19200	21600	26900
		TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	0.293	0.346	0.436
		TEQ <sub>P</sub> (ND = DL0)	ng/kg	10	100	--	--	normal	ucl.t	0.066	0.0802	0.104
		Semivolatile Organic Compounds										
		Bis(2-ethylhexyl)phthalate	µg/kg	10	0	210	210	all below DL	max	105	105	105
	FCA 2	Dioxins and Furans										
		TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	15	100	--	--	lognormal	ucl.cheb.log	4.42	19	27
		TEQ <sub>DF</sub> (ND = DL0)	ng/kg	15	100	--	--	lognormal	ucl.cheb.log	3.91	21.4	26.9
		Metals										
		Arsenic	mg/kg	15	100	--	--	normal	ucl.t	0.546	0.586	0.741
		Cadmium	mg/kg	15	100	--	--	normal	ucl.t	0.0274	0.0294	0.0351
		Chromium	mg/kg	15	100	--	--	lognormal	ucl.cheb.log	0.159	0.221	0.295
		Copper	mg/kg	15	100	--	--	lognormal	ucl.cheb.log	2.63	4.02	4.8
		Mercury	mg/kg	15	86.7	0.0088	0.0091	normal	ucl.t	0.00961	0.0114	0.0154
		Nickel	mg/kg	15	100	--	--	normal	ucl.t	1.18	1.3	1.6
		Zinc	mg/kg	15	100	--	--	normal	ucl.t	10.8	11.4	14
		Polychlorinated Biphenyls										
		Sum of 43 PCB Congeners (ND = 1/2DL)	ng/kg	15	100	--	--	lognormal	ucl.cheb.log	26000	50000	61800
		Sum of 43 PCB Congeners (ND = DL0)	ng/kg	15	100	--	--	lognormal	ucl.cheb.log	26000	50000	61800
		TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	15	100	--	--	lognormal	ucl.cheb.log	0.41	0.824	1.9
		TEQ <sub>P</sub> (ND = DL0)	ng/kg	15	100	--	--	lognormal	ucl.cheb.log	0.142	0.442	0.787
		Semivolatile Organic Compounds										
		Bis(2-ethylhexyl)phthalate	µg/kg	15	0	210	210	all below DL	max	105	105	105

**Table E-2**  
**Exposure Point Concentrations for Tissue, Baseline Conditions**

Tissue Type	Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Edible Crab	FCA 1	Dioxins/Furans										
		TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	0.739	1.07	1.91
		TEQ <sub>DF</sub> (ND = DLO)	ng/kg	10	100	--	--	normal	ucl.t	0.599	0.972	1.85
		Metals										
		Arsenic	mg/kg	10	100	--	--	normal	ucl.t	0.466	0.521	0.646
		Cadmium	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	0.0148	0.0244	0.0276
		Chromium	mg/kg	10	90	0.02	0.02	normal	ucl.t	0.047	0.0629	0.1
		Copper	mg/kg	10	100	--	--	lognormal	ucl.cheb.log	11.1	13.8	16.2
		Mercury	mg/kg	10	100	--	--	normal	ucl.t	0.0527	0.0577	0.0652
		Nickel	mg/kg	10	0	0.057	0.108	all below DL	max	0.042	0.054	0.054
		Zinc	mg/kg	10	100	--	--	normal	ucl.t	50.4	51.6	54.7
		Polychlorinated Biphenyls										
		Sum of 43 PCB Congeners (ND = 1/2DL)	ng/kg	10	100	--	--	lognormal	ucl.cheb.log	1160	3350	4820
		Sum of 43 PCB Congeners (ND = DLO)	ng/kg	10	100	--	--	lognormal	ucl.cheb.log	1080	3290	4740
		TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	0.119	0.148	0.234
		TEQ <sub>P</sub> (ND = DLO)	ng/kg	10	100	--	--	lognormal	ucl.cheb.log	0.00649	0.0201	0.0271
		Semivolatile Organic Compounds										
		Bis(2-ethylhexyl)phthalate	µg/kg	10	0	210	210	all below DL	max	105	105	105
	FCA 2/3	Dioxins/Furans										
		TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	20	60	0.164	0.376	lognormal	ucl.cheb.log	0.164	0.286	0.558
		TEQ <sub>DF</sub> (ND = DLO)	ng/kg	20	60	0.164	0.376	unknown	ucl.proucl.np	0.0617	0.176	0.523
		Metals										
		Arsenic	mg/kg	20	100	--	--	normal	ucl.t	0.426	0.459	0.596
		Cadmium	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	0.0103	0.0201	0.0494
		Chromium <sup>f</sup>	mg/kg	20	40	0.02	0.08	lognormal	ucl.cheb.log	0.00981	0.0261	0.09
		Copper	mg/kg	20	100	--	--	normal	ucl.t	10.4	11.1	15.4
		Mercury	mg/kg	20	100	--	--	normal	ucl.t	0.0339	0.0379	0.0522
		Nickel	mg/kg	20	0	0.043	0.135	all below DL	max	0.0348	0.0675	0.0675
		Zinc	mg/kg	20	100	--	--	normal	ucl.t	47.6	50	59.1
		Polychlorinated Biphenyls										
		Sum of 43 PCB Congeners (ND = 1/2DL)	ng/kg	20	100	--	--	lognormal	ucl.cheb.log	4710	7170	11400
		Sum of 43 PCB Congeners (ND = DLO)	ng/kg	20	100	--	--	lognormal	ucl.cheb.log	4660	7130	11300
		TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	20	100	--	--	lognormal	ucl.cheb.log	0.165	0.296	0.547
		TEQ <sub>P</sub> (ND = DLO)	ng/kg	20	100	--	--	unknown	ucl.proucl.np	0.0665	0.186	0.525

**Table E-2**  
**Exposure Point Concentrations for Tissue, Baseline Conditions**

Tissue Type	Exposure Unit	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
		Semivolatile Organic Compounds										
		Bis(2-ethylhexyl)phthalate	µg/kg	20	0	210	210	all below DL	max	105	105	105

**Reference**

USEPA, 2010. ProUCL Version 4.1.00 technical guide. EPA/600/R-07/041. May 2010.

**Notes**

-- = not applicable

95UCL = 95 percent upper confidence limit

COPC<sub>H</sub> = chemical of potential concern for human health

DL = detection limit

max = the maximum value was selected as the UCL in instances where the detection frequency was 0

Sum of 43 PCB Congeners - 1/2DL = Sum of 43 PCB congeners with nondetects set at one-half the detection limit

Sum of 43 PCB Congeners - DLO = Sum of 43 PCB congeners with nondetects set at zero

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = Nondetects set at zero.

PCB = polychlorinated biphenyl

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

UCL = upper confidence limit on the mean

ucl.t = upper confidence limit for normally distributed data, calculated based on the T statistic

ucl.cheb.log = upper confidence limit for lognormally distributed data, using a chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

a - All concentrations are on a wet weight basis unless the units indicate otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the central tendency exposure point concentration.

c - In line with the data treatment rules defined for this project, nondetected values were treated as one-half the DL in determining the mean and maximum concentrations. Exceptions are noted with DLO. In these cases nondetected concentrations were treated as 0.

d- The lower of the UCL and maximum will be used as the reasonable maximum exposure point concentration.

e - Because the detection frequency was between 20 and 50%,  $N \geq 10$ , and the distribution type was unknown, Kaplan Meier estimator was used for calculating the UCL.

f - Because the detection frequency was between 20 and 50%,  $N \geq 10$ , and the distribution type was lognormal, regression on order statistics (a method for substituting for nondetects) was used for calculating the UCL.

**Table E-3**  
**Exposure Point Concentrations for Soil North of I-10, Baseline Conditions**

COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>e,d</sup>
<b>Dioxins and Furans</b>										
TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	46	100	--	--	lognormal	ucl.cheb.log	4.53	22.6	153
TEQ <sub>DF</sub> (ND = DL0)	ng/kg	46	100	--	--	lognormal	ucl.cheb.log	4.18	23.8	152
<b>Metals</b>										
Arsenic	mg/kg	36	100	--	--	lognormal	ucl.cheb.log	2	3.8	9.4
Cadmium	mg/kg	36	91.7	0.008	0.05	lognormal	ucl.cheb.log	0.11	0.54	1.7
Chromium	mg/kg	36	100	--	--	lognormal	ucl.cheb.log	7.7	21	62
Copper	mg/kg	36	100	--	--	lognormal	ucl.cheb.log	8.24	29.7	121
Mercury	mg/kg	36	94.4	0.001	0.048	unknown	ucl.proucl.np	0.7	3	10
Nickel	mg/kg	36	97.2	0.5	0.5	lognormal	ucl.cheb.log	5.8	18	96
Zinc	mg/kg	36	100	--	--	lognormal	ucl.cheb.log	45	220	330
<b>Polychlorinated Biphenyls</b>										
Sum of Aroclors <sup>e</sup>	µg/kg	15	26.7	18	18	unknown	ucl.proucl.np	32.9	48.4	130
Sum of Aroclors (ND = DL0) <sup>e</sup>	µg/kg	15	26.7	171	171	unknown	ucl.proucl.np	32.9	48.4	130
TEQ <sub>B</sub> (ND = 1/2DL)	ng/kg	12	91.7	0.101	0.101	lognormal	ucl.cheb.log	0.541	2.65	2.83
TEQ <sub>B</sub> (ND = DL0)	ng/kg	12	91.7	0.101	0.101	lognormal	ucl.cheb.log	0.226	3.86	2.83
<b>Semivolatile Organic Compounds</b>										
Bis(2-ethylhexyl)phthalate	µg/kg	36	66.7	7	190	lognormal	ucl.cheb.log	36	220	990

**Reference**

USEPA, 2010. ProUCL Version 4.1.00 technical guide. EPA/600/R-07/041. May 2010.

**Notes**

-- = Not applicable

COPC<sub>H</sub> = chemical of potential concern for human health

DL = detection limit

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DL0 = nondetects set at zero

Sum of Aroclors = sum of detected Aroclor concentrations when one or more Aroclor was detected or one-half the maximum detection limit among the Aroclors when no Aroclors were detected

Sum of Aroclors (ND = DL0) = sum of total Aroclors with nondetects set at zero

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>B</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

UCL = upper confidence limit on the mean

ucl.cheb.log = UCL for lognormally distributed data, using a chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

a - All concentrations are on a dry weight basis unless the units indicated otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the central tendency exposure point concentration.

c - In line with the data treatment rules defined for this project, nondetected values were treated as one-half the DL in determining the mean and maximum concentrations. Exceptions are noted with DL0. In these cases nondetected concentrations were treated as 0.

d - The lower of the UCL and Maximum will be used as the reasonable maximum exposure point concentration.

e - Because the detection frequency was between 20 and 50%, N ≥ 10 and the distribution type was unknown, Kaplan Meier estimator was used for calculating the UCL.

**Table E-4**  
**Exposure Point Concentrations for Background Sediment**

COPC <sub>h</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
<b>Dioxins and Furans</b>										
TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	8	100	--	--	normal	ucl.t	0.4	0.607	0.952
TEQ <sub>DF</sub> (ND = DLO)	ng/kg	8	100	--	--	normal	ucl.t	0.301	0.513	0.886
<b>Metals</b>										
Arsenic	mg/kg	8	100	--	--	lognormal	ucl.cheb.log	0.403	0.967	1.25
Cadmium	mg/kg	8	63	0.2	0.2	lognormal	ucl.cheb.log	0.0909	0.176	0.22
Chromium	mg/kg	8	100	--	--	unknown	ucl.proucl.np	1.81	4.82	6.2
Copper	mg/kg	8	63	0.7	2.5	normal	ucl.t	1.36	1.93	3
Mercury <sup>a</sup>	mg/kg	7	57	0.003	0.009	lognormal	ucl.cheb.log	0.00272	0.00512	0.0045
Nickel	mg/kg	8	63	0.5	0.6	lognormal	ucl.cheb.log	0.907	3.93	4.73
Zinc	mg/kg	8	100	--	--	lognormal	ucl.cheb.log	4.31	10.3	15.1
<b>Polychlorinated Biphenyls</b>										
Sum of Aroclors (ND = 1/2 DL)	--	NA	--	--	--	--	--	--	--	--
Sum of Aroclors (ND=0)	--	NA	--	--	--	--	--	--	--	--
TEQ <sub>P</sub> (ND = 1/2DL) <sup>f</sup>	ng/kg	8	100	--	--	normal	ucl.t	0.165	0.198	0.222
TEQ <sub>P</sub> (ND = DLO)	ng/kg	11	73	0	0	unknown	ucl.proucl.np	0.005	0.01	0.01
<b>Semivolatile Organic Compounds</b>										
bis(2-Ethylhexyl)phthalate	µg/kg	8	13	19	19	unknown	ucl.proucl.np	10.8	16.5	20

**Reference**

USEPA, 2010. ProUCL Version 4.1.00 technical guide. EPA/600/R-07/041. May 2010.

**Notes**

-- = Not applicable

COPC<sub>h</sub> = chemical of potential concern for human health

DL = detection limit

NA = not available, no samples analyzed for this analyte at this exposure unit

RME = reasonable maximum exposure

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = nondetects set at zero

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

UCL = upper confidence limit on the mean

ucl.t = UCL for normally distributed data, calculated based on the T statistic

ucl.cheb.log = UCL for lognormally distributed data, using a Chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

a - All concentrations are on a dry weight basis unless the units indicated otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the central tendency exposure point concentration.

c - In line with the data treatment rules defined for this project, nondetected values were treated as one-half the DL in determining the mean and maximum concentrations. Exceptions are noted with DLO. In these cases nondetected concentrations were treated as 0.

d - The lower of the UCL and maximum will be used as the reasonable maximum exposure point concentration.

e - Outliers identified in statistical outlier analysis were removed from the dataset prior to calculation of exposure point concentrations.

f - High biasing nondetects were removed from the dataset prior to calculation of exposure point concentrations.

**Table E-5**  
**Exposure Point Concentrations for Background Tissue**

Tissue Type	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Hardhead Catfish Fillet	<b>Dioxins and Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	20	90	0.194	0.397	lognormal	ucl.cheb.log	0.474	1.65	4.97
	TEQ <sub>DF</sub> (ND = DLO)	ng/kg	20	90	0	0	lognormal	ucl.cheb.log	0.121	4.43	4.91
	<b>Metals</b>										
	Arsenic	mg/kg	10	100	--	--	normal	ucl.t	0.29	0.337	0.461
	Cadmium	mg/kg	10	10	0.001	0.0012	unknown	ucl.proucl.np	0.000875	0.00224	0.0037
	Chromium	mg/kg	10	0	0.02	0.06	all below DL	max	0.014	0.03	0.03
	Copper	mg/kg	10	20	0.29	0.94	unknown	ucl.proucl.np	0.617	1.78	2.39
	Mercury	mg/kg	10	100	--	--	normal	ucl.t	0.126	0.149	0.197
	Nickel <sup>e</sup>	mg/kg	9	0	0.012	0.048	lognormal	ucl.cheb.log	0.0116	0.0218	0.024
	Zinc	mg/kg	10	100	--	--	normal	ucl.t	13.9	15.9	20.2
	<b>Polychlorinated Biphenyls</b>										
	Total 43 PCB Congeners (ND = 1/2DL)	ng/kg	21	100	--	--	normal	ucl.t	48100	56800	98500
	Total 43 PCB Congeners (ND = 0)	ng/kg	21	100	--	--	normal	ucl.t	48100	56800	98500
	TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	21	100	--	--	unknown	ucl.proucl.np	0.977	1.65	2.29
	TEQ <sub>P</sub> (ND = DLO)	ng/kg	21	100	--	--	lognormal	ucl.cheb.log	0.292	0.75	2.12
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	10	0	210	210	all below DL	max	105	105	105
Edible Clam	<b>Dioxins and Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	0.364	0.47	0.702
	TEQ <sub>DF</sub> (ND = DLO) <sup>e</sup>	ng/kg	9	100	--	--	lognormal	ucl.cheb.log	0.139	0.397	0.63
	<b>Metals</b>										
	Arsenic	mg/kg	10	100	--	--	normal	ucl.t	0.491	0.528	0.576
	Cadmium	mg/kg	10	100	--	--	normal	ucl.t	0.0127	0.0138	0.0159
	Chromium <sup>e</sup>	mg/kg	9	100	--	--	normal	ucl.t	0.129	0.147	0.18
	Copper	mg/kg	10	100	--	--	normal	ucl.t	1.46	1.62	1.87
	Mercury	mg/kg	10	100	--	--	normal	ucl.t	0.00617	0.00674	0.008
	Nickel	mg/kg	10	100	--	--	unknown	ucl.proucl.np	1.2	1.45	1.39
	Zinc <sup>e</sup>	mg/kg	9	100	--	--	normal	ucl.t	9.82	10.5	12
	<b>Polychlorinated Biphenyls</b>										
	Total 43 PCB Congeners (ND = 1/2DL)	ng/kg	10	100	--	--	lognormal	ucl.cheb.log	8380	11900	12300
	Total 43 PCB Congeners (ND = 0)	ng/kg	10	100	--	--	unknown	ucl.proucl.np	8040	11700	12100
	TEQ <sub>P</sub> (ND = 1/2DL)	ng/kg	10	100	--	--	normal	ucl.t	0.181	0.212	0.283
	TEQ <sub>P</sub> (ND = DLO)	ng/kg	10	100	--	--	lognormal	ucl.cheb.log	0.0224	0.0384	0.0425
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	10	0	210	210	all below DL	max	105	105	105

**Table E-5**  
**Exposure Point Concentrations for Background Tissue**

Tissue Type	COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
Edible Crab	<b>Dioxins and Furans</b>										
	TEQ <sub>DF</sub> (ND = 1/2DL) <sup>f</sup>	ng/kg	20	30	0.145	0.534	unknown	ucl.proucl.np	0.126	0.183	0.639
	TEQ <sub>DF</sub> (ND = DL0) <sup>f</sup>	ng/kg	20	30	0	0	unknown	ucl.proucl.np	0.0299	0.092	0.594
	<b>Metals</b>										
	Arsenic	mg/kg	10	100	--	--	unknown	ucl.proucl.np	0.638	0.955	1.03
	Cadmium	mg/kg	10	100	--	--	unknown	ucl.proucl.np	0.00542	0.00935	0.0127
	Chromium	mg/kg	10	90	0.01	0.01	normal	ucl.t	0.0215	0.0273	0.04
	Copper	mg/kg	10	100	--	--	normal	ucl.t	7.37	7.62	8.27
	Mercury <sup>e</sup>	mg/kg	9	100	--	--	lognormal	ucl.cheb.log	0.0185	0.0231	0.0234
	Nickel	mg/kg	10	0	0.058	0.093	all below DL	max	0.0387	0.0465	0.0465
	Zinc	mg/kg	10	100	--	--	normal	ucl.t	45.1	46.3	47.6
	<b>Polychlorinated Biphenyls</b>										
	Total 43 PCB Congeners (ND = 1/2DL) <sup>e</sup>	ng/kg	9	100	--	--	normal	ucl.t	916	1050	1120
	Total 43 PCB Congeners (ND = 0) <sup>e</sup>	ng/kg	9	100	--	--	normal	ucl.t	826	960	1020
	TEQ <sub>P</sub> (ND = 1/2DL) <sup>e</sup>	ng/kg	9	100	--	--	normal	ucl.t	0.0821	0.0944	0.102
	TEQ <sub>P</sub> (ND = DL0)	ng/kg	10	100	--	--	normal	ucl.t	0.00423	0.00517	0.00704
	<b>Semivolatile Organic Compounds</b>										
	Bis(2-ethylhexyl)phthalate	µg/kg	10	0	210	210	all below DL	max	105	105	105

**Reference**

USEPA, 2010. ProUCL Version 4.1.00 technical guide. EPA/600/R-07/041. May 2010.

**Notes**

-- = not applicable

COPC<sub>H</sub> = chemical of potential concern for human health

DL = detection limit

max = the maximum value was selected as the UCL in instances where the detection frequency was 0

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DL0 = nondetects set at zero

PCB = polychlorinated biphenyl

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

UCL = upper confidence limit on the mean

ucl.t = UCL for normally distributed data, calculated based on the T statistic

ucl.cheb.log = UCL for lognormally distributed data, using a Chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

a - All concentrations are on a wet weight basis unless the units indicate otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the central tendency exposure point concentration.

c - In line with the data treatment rules defined for this project, nondetected values were treated as one-half the DL in determining the mean and maximum concentrations. Exceptions are noted with DL0. In these cases nondetected concentrations were treated as 0.

d - The lower of the UCL and maximum will be used as the reasonable maximum exposure point concentration.

e - Outliers identified in statistical outlier analysis were removed from the dataset prior to calculation of exposure point concentrations.

f - Because the detection frequency was between 20 and 50%, N > 10 and the distribution type was unknown, Kaplan Meier estimator was used for calculating the UCL.

**Table E-6**  
**Exposure Point Concentrations for Background Soil**

<b>COPC<sub>H</sub></b>	<b>Units<sup>a</sup></b>	<b>Number of Samples</b>	<b>Detection Frequency (percent)</b>	<b>Minimum Detection Limit</b>	<b>Maximum Detection Limit</b>	<b>Distribution Type</b>	<b>Method</b>	<b>Mean<sup>b, c</sup></b>	<b>95UCL<sup>d</sup></b>	<b>Maximum<sup>c, d</sup></b>
<b>Dioxins and Furans</b>										
TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	20	100	--	--	unknown	ucl.proucl.np	3.12	8.15	23.1
TEQ <sub>DF</sub> (ND = DL0)	ng/kg	20	100	--	--	lognormal	ucl.cheb.log	1.12	7.43	22.8
<b>Metals</b>										
Arsenic	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	2.19	4.05	5.25
Cadmium	mg/kg	20	85	0.029	0.037	lognormal	ucl.cheb.log	0.0914	0.355	0.842
Chromium	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	7.94	15.7	17.6
Copper <sup>e</sup>	mg/kg	19	100	--	--	normal	ucl.t	8.03	9.83	16
Mercury	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	0.0337	0.0704	0.137
Nickel	mg/kg	20	100	--	--	lognormal	ucl.cheb.log	5.37	14.7	19.7
Zinc	mg/kg	19	100	--	--	lognormal	ucl.cheb.log	30.6	95.6	276
<b>Polychlorinated Biphenyls</b>										
Sum of Aroclors <sup>e</sup>	µg/kg	19	0	19	19	all below DL	max	9.5	9.5	9.5
Sum of Aroclors (ND = DL0)	µg/kg	20	0	0	0	all below DL	max	0	0	0
TEQ <sub>P</sub> (ND = 1/2DL) <sup>e</sup>	--	NA	--	--	--	--	--	--	--	--
TEQ <sub>P</sub> (ND = DL0)	--	NA	--	--	--	--	--	--	--	--

**Table E-6**  
**Exposure Point Concentrations for Background Soil**

COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b, c</sup>	95UCL <sup>d</sup>	Maximum <sup>c, d</sup>
<b>Semivolatile Organic Compounds</b>										
Bis(2-ethylhexyl)phthalate <sup>f</sup>	µg/kg	19	57.9	7	510	unknown	ucl.proucl.np	22.7	61.9	150.

**Reference**

USEPA, 2010. ProUCL Version 4.1.00 technical guide. EPA/600/R-07/041. May 2010.

**Notes**

-- = Not applicable

COPC<sub>H</sub> = chemical of potential concern for human health

DL = detection limit

max = the maximum value was selected as the UCL in instances where the detection frequency was 0

NA = not available, no samples were analyzed for this analyte at this exposure unit

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = nondetects set at zero

RME = reasonable maximum exposure

Sum of Aroclors = sum of detected Aroclor concentrations when one or more Aroclor was detected or one-half the maximum detection limit among the Aroclors when no Aroclors were detected.

Sum of Aroclors (ND = DLO) = sum of total Aroclors with nondetects set at zero

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors

TEQ<sub>P</sub> = toxicity equivalent for polychlorinated biphenyls calculated using mammalian toxicity equivalency factors

UCL = upper confidence limit on the mean

ucl.t = UCL for normally distributed data, calculated based on the T statistic

ucl.cheb.log = UCL for lognormally distributed data, using a Chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

a - All concentrations are on a dry weight basis unless the units indicated otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the central tendency exposure point concentration.

c - In line with the data treatment rules defined for this project, nondetected values were treated as one-half the DL in determining the mean and maximum concentrations. Exceptions are noted with DLO. In these cases, nondetected concentrations were treated as 0.

d - The lower of the UCL and maximum will be used as the reasonable maximum exposure point concentration.

e - Outliers identified in statistical outlier analysis were removed from the dataset prior to calculation of exposure point concentrations.

f - High biasing nondetects were removed from the dataset prior to calculation of exposure point concentrations.

Table E-7

Exposure Point Concentrations for Surface Soil (0–6 inches), Area of Investigation on the Peninsula South of I-10

COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
<b>Dioxins and Furans</b>										
TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	26	100	--	--	lognormal	ucl.cheb.log	10.3	27.9	36.9
TEQ <sub>DF</sub> (ND = DL0)	ng/kg	26	100	--	--	lognormal	ucl.cheb.log	10	28.2	36.9
<b>Metals</b>										
Arsenic	mg/kg	22	100	--	--	unk	ucl.proucl.np	31	110	390
<b>Semivolatile Organic Compounds</b>										
Benzo(a)pyrene	µg/kg	11	100	--	--	lognormal	ucl.cheb.log	140	368	540

**Notes**

-- = Not applicable

COPC<sub>H</sub> = chemical of potential concern for human health

CT = central tendency

DL = detection limit

EPC = exposure point concentration

RME = reasonable maximum exposure

TEQ<sub>DF</sub> (ND = 1/2DL) = toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors with nondetects set at one-half the detection limitTEQ<sub>DF</sub> (ND = DL0) = toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors with nondetects set at zero

UCL = upper confidence limit on the mean

ucl.cheb.log= UCL for lognormally distributed data, using a Chebyshev correction factor

ucl.proucl.np= nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

unk= unknown distribution

a - All concentrations are on a dry weight basis unless the units indicate otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the CT EPC.

c - In line with the data treatment rules defined for this project, non-detected values were treated as 1/2 the DL in determining the mean and maximum concentrations. Exceptions are noted with DL0. In these cases non-detected concentrations were treated as 0.

d - The lower of the UCL and maximum will be used as the RME EPC.

Table E-8

## Exposure Point Concentrations for Subsurface Soil (0-12 inches), Area of Investigation on the Peninsula South of I-10

COPC <sub>H</sub>	Units <sup>a</sup>	Number of Samples	Detection Frequency (percent)	Minimum Detection Limit	Maximum Detection Limit	Distribution Type	Method	Mean <sup>b,c</sup>	95UCL <sup>d</sup>	Maximum <sup>c,d</sup>
<b>Dioxins/Furans</b>										
TEQ <sub>DF</sub> (ND = 1/2DL)	ng/kg	26	100	--	--	lognormal	ucl.cheb.log	10.7	24.6	36.9
TEQ <sub>DF</sub> (ND = DL0)	ng/kg	26	100	--	--	lognormal	ucl.cheb.log	10.5	24.7	36.9
<b>Metals</b>										
Arsenic	mg/kg	22	100	--	--	unk	ucl.proucl.np	30	97	320
<b>Semivolatile Organic Compounds</b>										
Benzo(a)pyrene	µg/kg	11	100	--	--	lognormal	ucl.cheb.log	116	345	445

**Notes**

-- = Not applicable

COPC<sub>H</sub> = chemical of potential concern for human health

CT = central tendency

DL = detection limit

EPC = exposure point concentration

RME = reasonable maximum exposure

TEQ<sub>DF</sub> (ND = 1/2DL) = Toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors with nondetects set at one-half the detection limit.

TEQ<sub>DF</sub> (ND = DL0) = Toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors with nondetects set at zero.

UCL = upper confidence limit on the mean

ucl.cheb.log = UCL for lognormally distributed data, using a Chebyshev correction factor

ucl.proucl.np = nonparametric UCL for an unknown data distribution, same method as ProUCL (USEPA 2010)

unk = unknown distribution

a - All concentrations are on a dry weight basis unless the units indicate otherwise.

b - Means are determined as appropriate for the distribution of the data. The mean value is the CT EPC.

c - In line with the data treatment rules defined for this project non-detected values were treated as 1/2 the DL in determining the mean and maximum concentrations. Exceptions are noted with DL0. In these cases non-detected concentrations were treated as 0.

d - The lower of the UCL and Maximum will be used as the RME EPC.

**APPENDIX F**  
**POST-TCRA EXPOSURES AND RISKS FOR**  
**THE AREA NORTH OF I-10 AND AQUATIC**  
**ENVIRONMENT: METHODS AND**  
**RESULTS**

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# APPENDIX F

## POST-TCRA EXPOSURES AND RISKS FOR THE AREA NORTH OF I-10 AND AQUATIC ENVIRONMENT: METHODS AND RESULTS

### SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

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**Prepared for**

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International Paper Company  
U.S. Environmental Protection Agency, Region 6

**Prepared by**



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**December 2012**

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## LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
AICc	Akaike's Information Criterion
BHHRA	baseline human health risk assessment
COPC	chemical of potential concern
CWA	Coastal Water Authority
EAM	Exposure Assessment Memorandum
EPC	exposure point concentration
FCA	fish collection area
HI	hazard index
HQ	hazard quotient
Integral	Integral Consulting Inc.
MIMC	McGinnes Industrial Maintenance Corporation
MLR	multiple linear regression
PCDD	polychlorinated dibenzo- <i>p</i> -dioxin
PCDF	polychlorinated dibenzofuran
Site	San Jacinto River Waste Pits site in Harris County, Texas
SWAC	surface area-weighted concentration
TCDD	tetrachlorodibenzo- <i>p</i> -dioxin
TCDF	tetrachlorodibenzofuran
TCRA	time-critical removal action
TEF	toxicity equivalence factor
TEQ	toxicity equivalent
TEQ <sub>DF</sub>	toxicity equivalent for dioxins and furans
TOC	total organic carbon
TMDL	total maximum daily load
USEPA	U.S. Environmental Protection Agency
ww	wet weight

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## 1 INTRODUCTION

The Exposure Assessment Memorandum (EAM) (Integral 2102) states that the baseline human health risk assessment (BHHRA) will present an evaluation of potential risks associated with dioxin and furan exposures under the current conditions at San Jacinto River Waste Pits site in Harris County, Texas (the Site)<sup>1</sup>, that is, following implementation of the time-critical removal action (TCRA). Although they are not considered part of the baseline condition, post-TCRA conditions were evaluated as part of the BHHRA to support consideration of the TCRA as part of the final remedy for the Site.

This appendix presents the methods used for calculating post-TCRA exposures and estimated risks and the results of the post-TCRA risk evaluation. First, it provides an overview of the post-TCRA condition and the specific hypothetical exposure scenarios evaluated. Next, it details the analysis steps and assumptions that were used in calculating post-TCRA exposure point concentrations (EPCs) for sediment, soils, and edible tissue (i.e., edible crab, catfish fillet, and edible clams). Exposure units for the post-TCRA analysis and the specific samples used to calculate EPCs were presented in the EAM, and are reviewed here. Methods for estimating tissue concentrations were briefly described in the EAM (Integral 2012, Appendix A), and are presented in greater detail below. Following the discussion of EPCs, the findings of the post-TCRA risk characterization are presented, including a comparison to baseline risks.

## 2 POST-TCRA SETTING AND HYPOTHETICAL EXPOSURE SCENARIOS

The TCRA consisted of the installation of an armored cap and implementation of institutional controls, including fencing and warning signs. The installation of the armored cap was completed in July 2011, and the fencing and other institutional controls were implemented prior to that date. Through the installation of geotextile and geomembrane underlayments and a granular cover, the TCRA stabilized the entire area within the 1966 perimeter of the impoundments north of I-10 (the TCRA Area) (Figure F-1). The Coastal Water Authority (CWA) also installed fencing that limits access to the shoreline on the east side of the channel under the I-10 Bridge; the placement of those fences is shown in

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<sup>1</sup> References to "the Site" in this document are intended as reference to the formally designated Superfund site and not to a geographical area.

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Figure F-2. The condition that resulted from construction of the TCRA cap and the installation of fencing (including the CWA-installed fencing) collectively are described in this document as the “post-TCRA” condition.

The post-TCRA evaluation of potential human health risks was completed only for dioxins and furans, and for those scenarios that met one or more of the following threshold criteria:

- (1) The cumulative exposure from all pathways resulted in a total endpoint-specific noncancer hazard index [HI]>1,
- (2) The cumulative exposure from all pathways resulted in a dioxin cancer HI>1.

The EAM identified two discrete exposure areas for human exposures to edible crab and catfish, fish collection area (FCA) 1 and FCA 2 combined with FCA 3 (termed “FCA 2/3” throughout this Appendix); the post-TCRA analysis also uses this framework to estimate hypothetical exposures to human receptors. This distinction primarily affects the approach to estimating tissue concentrations.

### **3 POST-TCRA EXPOSURES TO SOIL AND SEDIMENT**

Fencing installed by Respondents International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC) as part of the TCRA and by CWA TCRA limits access to the impoundments north of I-10, to areas immediately west of these impoundments, and to the eastern shore of the San Jacinto River adjacent to I-10. For the post-TCRA analysis, it was assumed that hypothetical fishers will not access these shorelines via boat and therefore, access to these areas will be completely restricted. In addition, the TCRA cap itself eliminates the potential for direct contact with materials within the original 1966 impoundment perimeter north of I-10. Therefore, under post-TCRA conditions, the only sediments that remain accessible for human contact are those in Beach Area A, which was not capped. The EPC established for this beach area was adopted for the post-TCRA EPC (Table F-1). Figure F-3 illustrates this post-TCRA exposure unit for sediments.

For soils, only six samples fall within the area north of I-10 that remains potentially accessible to human contact following the TCRA: SJTS028, -029, -030, -and -031, and TxDOT001 and -007. Therefore, these six samples were used in calculating the post-TCRA

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EPC for soils (Table F-1). Figure F-4 shows the sampling locations used to define the post-TCRA exposure unit for soils.

## **4 POST-TCRA EXPOSURE TO EDIBLE TISSUES**

No tissue data are available to represent the post-TCRA condition. Consistent with the EAM, post-TCRA tissue concentrations of dioxins and furans were estimated for catfish fillet, clams, and crabs. For catfish fillet and edible crab tissue, regression equations developed in the *Technical Memorandum on Bioaccumulation Modeling* (Bioaccumulation Tech Memo) (Integral 2010) were used initially. However, as described below, regression models for crab clearly over-predicted post-TCRA tissue concentrations, and there are no regression models available to estimate post-TCRA dioxin and furan concentrations in clams. Therefore, for edible crab and clam the available empirical data were used to represent post-TCRA concentrations. The rationale supporting final data selection for post-TCRA tissue concentrations is summarized in Section 4.2.

### **4.1 Regression Models Used to Estimate Tissue Concentrations**

Only those congeners with statistically significant regression equations reported by Integral Consulting Inc. (Integral) (2010) for edible crab tissue and catfish fillet are addressed by this analysis. Because the models used are the result of multiple linear regression modeling, several variables were required to populate each calculation. This section reviews the available regression models, their application, and the derivation of each parameter required to populate each equation.

The following discussion was originally presented in the Bioaccumulation Tech Memo (Integral 2010), and is repeated here for convenience. Integral (2010) investigated and characterized statistical relationships between concentrations of each dioxin congener in edible crab and catfish fillet with corresponding concentrations in sediment using both bivariate and multivariate statistics (Integral 2010). Results of the bivariate evaluations (Tables F-2 and F-3), which found significant correlations between concentrations in sediment and in catfish fillet or edible crab tissue for 8 congeners, were used to determine which congener concentrations could potentially be explained in tissue using multiple environmental variables.

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All of the congeners with significant bivariate correlation between sediment and crab tissue concentrations (Table F-2) were further investigated using multiple linear regression (MLR) analysis. The best fitting models (determined based on the modified Akaike's Information Criterion [AICc]) for dioxin and furan concentrations in crab tissue are summarized in Table F-4. Consistent with results of the bivariate correlation analysis, tetrachlorodibenzo-*p*-dioxin (TCDD) and tetrachlorodibenzofuran (TCDF) were the congeners with the strongest relationship between crab tissue and sediment, as indicated by the R-square values. However, even the best fitting models left approximately 45 percent of the variance unexplained. Both total organic carbon (TOC) and tissue lipid content were significant covariates. Interestingly, the best-fit models for both TCDD and TCDF do not contain the sediment concentrations as first-order terms, but rather only contain their interactions with sediment organic carbon, tissue lipid content, and season (Table F-4). Interaction terms represent the combined effect of two or more variables when their effects are not additive. For example, the concentration of an organic chemical in fish tissue is commonly assumed to be related to the chemical concentration in sediment divided by the TOC content of sediment. In this case, the effects of the sediment chemistry and TOC concentrations are multiplicative, not additive. Interaction terms in linear models represent these types of effects. Interaction terms may include more complex interactions than the simple proportionality that is represented by a ratio of chemical concentration to TOC content.

Bivariate correlations between sediment and catfish fillet tissue (Table F-3) show that only TCDD and TCDF have meaningful statistical relationships. The other congeners either had weak relationships ( $\tau\text{-}b < 0.3$ ), negative relationships, or did not show a correlation at all (Table F-3). MLR analysis was used to further investigate sediment-tissue relationships only for those two congeners (i.e., TCDD and TCDF) (Table F-3). The best fitting models (based on AICc) for TCDD and TCDF concentrations in catfish fillet are summarized in Table F-5. Paralleling the bivariate correlations analysis, even the best fitting models left more than 40 percent of the variance unexplained. In the case of catfish fillet tissue, significant contributors to the explanatory power of the model include season, TOC, and tissue lipid content. As for the MLR results with crab tissue, the best-fit model for TCDF did not contain sediment concentration as a first-order term, but only the interaction terms with sediment organic carbon, catfish tissue lipid content, and season (Table F-5).

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The results from the MLR analysis provide regression models for only a partial list of congeners for edible crab and catfish fillet. The fact that not all congeners are represented poses a limitation when extending this model to the calculation of post-TCRA tissue concentrations, especially in the subsequent generation of a post-TCRA toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors (TEQ<sub>DF</sub>). Integral (2010) presented the average contribution of each congener to the total mass of dioxins and furans for the edible crab and catfish tissue data on which the regression analysis was based, and these percentages are shown in Table F-6. For edible crab, the sum of the average contributions of each congener for which significant regression models are available to total mass of dioxin and furan concentrations is 77.4 percent. For catfish fillet, this number is 31.7 percent. Therefore, use of only the congener-specific regression models could result in an underestimate of the post-TCRA TEQ<sub>DF</sub> in edible crab and catfish fillet.

As explained in the Bioaccumulation Tech Memo (Integral 2010, pp. 31-32): "...because uptake, excretion, and metabolism are congener-dependent both in terms of mechanics and rates, bioaccumulation of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs) cannot be understood on the basis of aggregate quantities, such as toxicity equivalent (TEQ) concentrations. Therefore, aggregate variables (such as TEQ) in exposure media will not be used to predict TEQ in tissue unless they can be verified for the species that are the subject of the prediction in the environment of interest, and if they provide a verifiably better means of prediction than congener-specific models using site-specific data." Not setting aside the recognition of important limitations and caveats that surround the use of TEQ<sub>DF</sub> in regression analysis (i.e., on the basis of differences among congeners in uptake, metabolism and excretion rates, interspecies variability in these parameters, and the general lack of significant relationships for individual congener concentrations between sediment and tissue), regression models based on TEQ were also considered for this analysis because the available congener-specific regression models only address a small subset of the congeners.

Regression models using TEQ<sub>DF</sub> concentrations were derived for both edible crab and catfish fillet using the same methods and the same data sets used in the Bioaccumulation Tech Memo (Integral 2010). Resulting models and data transformations are described in Tables F-7 through F-11. Predictions using these models are compared to predictions using

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the congener-specific approach (Table F-12), providing the basis for a discussion of uncertainty in the characterization of post-TCRA estimated risks.

Only congeners for which MLR equations were developed were used to estimate post-TCRA concentrations of each congener in edible crab and catfish fillet. A second analysis was conducted for post-TCRA estimations based upon multilinear equations developed using TEQ<sub>DF</sub>. To do this, several parameter estimates were required, including:

- Season
- TOC
- Percent lipid
- Concentration in sediment.

Methods and assumptions to derive each of these are provided below.

#### **4.1.1 Season**

As described in the Bioaccumulation Tech Memo (Integral 2010), season was among the variables evaluated in the MLR analysis. As part of the TCEQ total maximum daily load (TMDL) program (University of Houston and Parsons 2006), sampling events were conducted seasonally, and this information was included in the regression analysis as a categorical variable. The MLR models used to predict tissue concentrations for the post-TCRA risk analysis included some for which season was among the coefficients. In these cases, fall was chosen (S=fall; Tables F-4 and F-5) because the range of concentrations of dioxins and furans in sediment among the TMDL data set for that season was similar to the range of concentrations in the post-TCRA sediment environment. If a model had a seasonal coefficient other than fall (e.g., Table F-11), then the coefficient was zero.

#### **4.1.2 Total Organic Carbon in Sediments**

TOC data used to generate the MLR equations were first transformed to approximate the necessary assumptions of multivariate normality as described in the Bioaccumulation Tech Memo (Integral 2010). The Shapiro-Wilk goodness-of-fit test showed that sediment TOC values required a square root transformation procedure (Tables F-7 and F-8). For congener specific and TEQ-based post-TCRA calculations, the median TOC value (mg/kg) from the

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baseline data set was calculated and transformed as described above for use as a point-estimate for the TOC term in Tables F-4, F-5, and F-11.

#### **4.1.3 Percent Lipid**

Percent lipid data used to generate the MLR equations were first transformed to approximate the necessary assumptions of multivariate normality as described in the Bioaccumulation Tech Memo (Integral 2010). The Shapiro-Wilk goodness-of-fit test showed that lipid values required a natural log transformation procedure for catfish and square root for crab (Tables F-9 and F-10). The L terms in Tables F-4, F-5, and F-7 were generated by computing the median value for each tissue type followed by the required transformation for congener specific and TEQ-based estimates.

#### **4.1.4 Concentration in Sediment**

For the sediment concentration term (i.e.,  $C_s$ ) in the equations presented in Tables F-4, F-5, and F-7, congener-specific surface area-weighted concentrations (SWACs) of each congener in sediment of the two human exposure units for edible crab tissue and catfish fillet (FCA 1 and FCA 2/3) were required. Sediment samples, the large majority of which were collected in 2010, represent baseline conditions (i.e., immediately prior to the TCRA). To estimate post-TCRA SWACs, exposure unit-specific SWACs were first calculated using Thiessen polygons.

A Thiessen polygon is defined as the area around a sampling location that includes all points in space that are closer to that sampling location than they are to any other sampling location. The polygon-specific percent of the FCA or exposure unit area described by each Thiessen polygon provides a factor used to weight the concentration of the subject chemical at the sampling location that the polygon represents. These weighted values are then summed to generate the FCA-specific SWAC for that chemical. In this way, for each sampling station and sample, the chemical concentration at a given location is weighted by the area represented by the polygon for that station. Area-weighting of surface sediment concentrations using Thiessen polygons is a well-established method of accounting for different spatial sampling densities within and across sampling programs.

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#### **4.1.4.1      *Sediment Data Selected***

For this evaluation, Thiessen polygons were generated using data for surface sediment sampling locations. To do this, those samples with an upper depth of 0 cm were included in the polygon calculations. The lower depths of these surface sediment chemistry data are typically 6 inches, but can reach up to 12 inches. Also, within the 1966 perimeter of the impoundments north of I-10, some sampling locations were in areas that were not typically subtidal or were barely intertidal. Because these locations would not come into contact with the water during regular tidal cycles, they were excluded from SWAC calculations because fish and crabs would not regularly be exposed to them. These sampling locations were all at least 50 feet inland from the shoreline.

Also, five pairs of co-located grab/core samples were collected during the remedial investigation sediment study: SJNE008, SJNE023, SJNE028, SJNE041, and SJNE043. These were plotted as single points because multiple Thiessen polygons cannot be calculated for co-located points. In these cases, concentration data were always sourced from the grab samples rather than from the core samples; grab samples include material from 0 to 6 inches below the surface, whereas core samples include material from 0 to 12 inches below the surface. In all cases, where sampling locations were proximal but not co-located, separate Thiessen polygons were derived.

#### **4.1.4.2      *GIS Generation of Thiessen Polygons***

For locations at which surface sediment concentrations for each dioxin and furan congener were available, data were plotted using the northing and easting coordinates, and projected into the North American Datum 1983 State Plane Texas South Central Zone, FIPS 4204 Feet coordinate system.

To represent the post-TCRA sediment conditions, Thiessen polygons were created separately for FCA 1 and for FCA 2/3. For FCA 1, qualifying sampling locations that fell within the exposure unit boundary were used to generate the set of polygons. Once the polygons were created, they were then clipped to the shoreline boundary, which removed those portions of

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the Thiessen polygons located in upland areas. They were also clipped at U.S. Environmental Protection Agency's (USEPA) Preliminary Site Perimeter.<sup>2</sup>

For FCA 2/3, sampling locations inside the TCRA boundary were considered separate from the exterior area, such that no Thiessen polygon could straddle the TCRA boundary. Sampling locations were divided into two groups: 1) those inside the TCRA boundary, and 2) those outside the TCRA boundary. Thiessen polygons were then generated separately for these two datasets. Those created from points inside the TCRA were clipped using the TCRA boundary and the shoreline boundary. Those created from points outside the TCRA boundary were clipped using the shoreline boundary and USEPA's Preliminary Site Perimeter; the areas from these Thiessen polygons falling within the TCRA boundary were then removed to avoid any possible overlap with those polygons generated within the TCRA boundary. These two sets of polygons—inside and outside the TCRA boundary—were then merged together to create a seamless Thiessen polygon dataset characterizing the surface concentrations for the entire FCA 2/3 area.

Final editing of the Thiessen polygons was performed to ensure that they were not separated by land masses. In some cases, land in the form of an island or peninsula divided post-clipped polygons. In these instances, polygons were trimmed, merged, or otherwise edited so that they were attributed to the nearest point, forming a contiguous, discrete polygon that would reflect reasonable continuity in actual exposure areas for fish or crabs. This eliminated situations in which a small region of water was attributed to a sampling location on the other side of an upland land mass (Figure F-5). After all clipping and editing was complete, the final areas of each polygon were calculated in the local projection and exported for SWAC calculation (Table F-13).

#### **4.1.4.3      *Surface Area-Weighted Average Concentration Calculation***

The exported Thiessen polygon areas were combined with the database of the dioxin and furan congener concentrations for each sampling location. To calculate the SWAC for each scenario, the following equation was used:

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<sup>2</sup> For the purposes of this document, the term "USEPA's Preliminary Site Perimeter" refers to the area shown within the "preliminary perimeter" in Appendix B of the UAO.

$$SWAC = \sum (\text{Area of station-specific polygon} / \text{Area FCA}) \times \text{Station-specific congener concentration}$$

Eq. 4-1

Each polygon had a unique congener concentration. There were two exceptions to this: 1) for locations where grab samples were co-located with core samples, the concentrations from the grab samples were used in calculating the SWAC rather than the core values; 2) for sampling locations within the TCRA boundary, median concentrations for each congener were used rather than unique values from individual sampling locations. These median values were each multiplied by the qualifying fractional area (i.e., the sum of the final Thiessen polygon areas within the TCRA boundary). This affected a total of 25 sampling locations: TCEQ2009\_Point03, TCEQ2009\_Point04, TCEQ2009\_Point05, SJB1, SJB2, SJC1, SJC2, SJD1, SJD2, SJE1, SJE2, SJGB004, SJGB005, SJGB007, SJGB008, SJGB013, SJGB014, SJGB015, SJGB016, SJGB017, SJNE022-1, SJNE022-2, SJNE022-3, SJSH008, and SJSH009.

Once the multiplication was complete for all sampling locations in a given scenario, the resulting set of values for each congener was summed, yielding the SWAC for that congener. Repeating the process for each scenario ultimately produced a SWAC for each congener for each of the two exposure units (Table F-14). These congener-specific SWACs were then multiplied by the appropriate toxicity equivalence factor (TEF) (van den Berg et al. 2006) to calculate the corresponding TEQ<sub>DF</sub> values for each exposure area.

#### **4.1.5 Post-TCRA Tissue Concentration Estimates**

Estimates of dioxin and furan congener concentrations in edible crab and catfish fillet tissue under post-TCRA conditions were first calculated for those congeners for which MLR models were available. Post-TCRA calculations were also conducted using regression models on TEQ<sub>DF</sub> concentrations to account for a possible underestimation of TEQ when using congener-specific models. Values for the sediment concentrations and covariates, tissue lipid content, sediment TOC, and season were applied as described above. The sediment SWACs were transformed to approximate normality using the Shapiro-Wilk test to determine the best transformation procedure (Tables F-7 and F-8). Resulting post-TCRA estimates for

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individual congeners and TEQ<sub>DF</sub> in both edible crab and catfish fillet tissue are presented in Table F-12.

Predicted tissue concentrations for individual congeners in edible crab ranged from 0.74 to 3.23 ng/kg (wet weight [ww]) in FCA 1 and from 0.72 to 3.24 ng/kg (ww) in FCA 2/3. Little difference in the predicted values was observed between the two exposure areas. The calculated TEQ<sub>DF</sub> based on the congener specific estimates was 1.458 and 1.461 ng/kg in FCA 1 and FCA 2/3, respectively. Table F-12 additionally presents the lower and upper 95 percent confidence intervals, which result in an upper estimate for TEQ<sub>DF</sub> in edible crab of 2.46 ng/kg for each exposure area. Predictions based on the MLR analysis of TEQ<sub>DF</sub> were similar to those based on congener-specific MLR analyses. TEQ<sub>DF</sub> based predictions were 1.76 and 1.72 for the two exposure areas FCA 1 and FCA 2/3, respectively. These values exceed those determined using congener-specific MLR analyses, but remain within 20 percent of the congener based post-TCRA estimates of TEQ<sub>DF</sub>.

Results for catfish fillet showed similar patterns. Predicted TCDD concentrations were 2.31 and 2.16 ng/kg (ww) while predicted TCDF concentrations ranged from 1.07 to 1.07 ng/kg (ww) in FCA 1 and FCA 2/3, respectively. The calculated TEQ<sub>DF</sub> based on estimated TCDD and TCDF concentrations were 2.41 ng/kg in FCA 1 and 2.27 ng/kg in FCA 2/3. Upper confidence intervals (95 percent) estimated TEQ<sub>DF</sub> of 2.89 ng/kg (FCA 1) and 2.71 ng/kg (FCA 2/3). As in the edible crab tissue, predictions based on TEQ<sub>DF</sub> for catfish fillets resulted in values similar to those estimated using congener specific MLR analyses. TEQ<sub>DF</sub> based predictions in catfish fillets resulted in values of 2.17 ng/kg and 2.03 ng/kg in FCA 1 and FCA 2/3, respectively. These values were lower by about 12 percent than TEQ<sub>DF</sub> concentrations estimated using individual TCDD and TCDF models.

#### **4.1.6 Post-TCRA Estimates Relative to Baseline**

The post-TCRA sediment condition, as represented by the spatial model described above, reflects a general lowering of the concentrations of dioxins and furans in sediment. Those regression models with positive slopes indicate that a reduction in sediment concentrations will affect a corresponding reduction in tissue concentrations. This is also the assumption underlying any remedial action involving sediment removal or capping. Therefore, modeled

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tissue concentrations using estimated post-TCRA conditions can reasonably be expected to be lower than baseline tissue concentrations. Therefore, to evaluate the realism of the predicted congener and TEQ concentrations in edible crab and catfish fillet tissue, results were compared to summary statistics for these tissues presented in the *Preliminary Site Characterization Report* (Integral and Anchor QEA 2012). The mean values in each FCA from those summary statistics from the *Preliminary Site Characterization Report* are presented here as Tables F-15 and F-16, respectively.

For edible crab, simple comparison between the mean concentrations of each congener predicted for FCA 1 with baseline concentrations indicates that, especially for the furans, the regression models predict post-TCRA tissue concentrations that exceed baseline by factors ranging from 0.6 to 43. The regression model based on TEQ<sub>DF</sub> predicted a concentration 2.3 times the baseline concentration for FCA 1, and the regression model for exposure unit FCA 2/3 predicted TEQ<sub>DF</sub> concentrations that exceed baseline concentrations in FCA 2 and FCA 3 by an even greater amount. For edible crab, comparisons of both congener-specific and TEQ<sub>DF</sub>-based predictions with means of the baseline concentrations for the respective individual FCAs yield similar conclusions: if tissue concentrations of dioxins and furans are expected to be reduced with reductions in sediment concentrations, then regression models derived for the Bioaccumulation Technical Memo over-estimate actual post-TCRA tissue concentrations.

Congener-based predictions for catfish fillet were greater than baseline for 2,3,7,8-TCDF, and somewhat lower for 2,3,7,8-TCDD, in both exposure units. The TEQ<sub>DF</sub>-based predictions for catfish in FCA 1 and FCA 2/3 (2.17 ng/kg ww and 2.03 ng/kg ww, respectively), were somewhat lower than the actual baseline mean TEQ<sub>DF</sub> in catfish fillet in these areas (2.94 ng/kg ww and 3.29-3.87 ng/kg ww, respectively). Although the modeled concentrations are somewhat lower than the baseline mean values, the values derived from the regression models may underestimate actual reductions in catfish fillet tissue concentrations as a result of the TCRA, particularly for 2,3,7,8-TCDF.

Because comparison of the predicted concentrations with actual concentrations indicates a likely significant overestimate of post-TCRA concentrations in crab based on regression modeling, the post-TCRA exposure evaluation for the BHHRA does not use modeled values

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for crab. Instead, an alternative approach using baseline data was used for edible crab, as discussed below. Although the regression approach may also overestimate post-TCRA concentrations in catfish fillet, predicted concentrations of TEQ<sub>DF</sub> in catfish fillet resulting from the regression models were still considered useful for the post-TCRA exposure evaluation. This is because predicted concentrations indicated some reduction in the catfish TEQ<sub>DF</sub> tissue levels, which is consistent with the conceptual framework of the regression models and the post-TCRA scenario, i.e., that the TCRA has significantly reduced or eliminated exposure of fish to COPCs in the area addressed by the TCRA.

In the absence of empirical information on actual post-TCRA tissue conditions, the catfish fillet regression model provides a usable estimate for this analysis. However, the instances described above, where a disparity exists between the conceptual framework supporting the use of regression models and the results of their application being much greater than actual concentrations under baseline conditions, highlight the significant uncertainty associated with predicting tissue concentrations from sediment concentrations of dioxins and furans.

## 4.2 Final Tissue EPCs

In light of the uncertainties with the edible crab and catfish fillet predictions identified in Section 4.1.6, and in the absence of models to predict post-TCRA clam concentrations, final post-TCRA tissue EPCs for dioxins and furans were determined as follows:

- Catfish Fillet. Two sets of EPCs were derived using the regression modeling. The first was based on modeling individual dioxin and furan congeners, while the second was based on modeling TEQ<sub>DF</sub>. Both sets of catfish EPCs were applied for the post-TCRA risk characterization (Table F-1).
- Crabs. In the absence of acceptable models or any other information on post-TCRA concentrations of dioxin and furan congeners in crabs, post-TCRA conditions were represented by baseline data for edible crab for this evaluation (Table F-1).
- Clams. Clams collected from Transect 3 were sampled directly adjacent to the impoundments north of I-10. Transect 3 was positioned within the original 1966 perimeter of the impoundments north of I-10 (Figure F-6). Because the TCRA directly addressed sediments in the area of Transect 3, clam tissue EPCs for post-TCRA conditions were recalculated without clam data for Transect 3–Transect 3

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clams were removed from the data set and EPCs were re-calculated (Table F-1).

## 5 POST-TCRA EXPOSURE AND RISK CHARACTERIZATION

Noncancer and cancer TEQ<sub>DF</sub> HIs were calculated for all hypothetical exposure scenarios for which cumulative noncancer and/or cancer HIs were greater than 1 in the baseline deterministic evaluation. These included:

- Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3 (Scenario 3A) (hypothetical recreational and subsistence fishers)
- Direct exposure Beach Area E; Ingestion of clam from FCA 2 (Scenario 3B) (hypothetical recreational and subsistence fishers)
- Direct exposure Beach Area E; Ingestion of crab from FCA 2/3 (Scenario 3C) (hypothetical recreational and subsistence fishers)
- Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3 (Scenario 1A) (hypothetical subsistence fishers only)
- Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3 (Scenario 2A) (hypothetical subsistence fishers only)
- Direct exposure Beach Area B/C; Ingestion of clam from FCA 2 (Scenario 2B<sup>3</sup>) (hypothetical subsistence fishers only)
- Direct exposure Beach Area D; Ingestion of catfish from FCA 1 (Scenario 4A) (hypothetical subsistence fishers only)
- Direct exposure Beach Area E and soils north of I-10 (Scenario 3) (hypothetical recreational visitors).

Results for individual pathways within these hypothetical exposure scenarios are presented, and risk is evaluated for each scenario using appropriate combinations of individual pathway results.

In addition to the estimated post-TCRA noncancer and cancer hazards for each of these hypothetical exposure scenarios, a metric that represents the estimated hazard reduction

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<sup>3</sup> For this scenario only, the resulting noncancer hazard reached the threshold established (i.e., a cumulative hazard across all COPCs and all exposure pathways > 1) for completing additional post-TCRA analysis.

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resulting from TCRA implementation was calculated for each scenario. This metric, termed here the “TEQ<sub>DF</sub> hazard reduction,” was calculated as:

$$TEQ_{DF} \text{ Hazard Reduction} = 1 - \frac{PostTCRA \text{ HI} - background \text{ HI}}{Baseline \text{ HI} - background \text{ HI}}$$

Eq. 5-1

The results of the post-TCRA risk characterization for noncancer and cancer effects are presented below. For those hypothetical exposure scenarios that assumed ingestion of catfish, post-TCRA estimates using both the TEQ and congener approach for estimating EPCs are presented.

## 5.1 Noncancer Hazard

Table F-17 displays the estimated noncancer TEQ<sub>DF</sub> hazard quotient (HQ) for individual pathways that make up the hypothetical exposure scenarios evaluated for post-TCRA conditions. In the instance that exposure to sediments at Beach Area E was a pathway included in the scenario selected for the post-TCRA analysis, estimated non-cancer hazards that resulted from exposure to sediments at Beach Area A are shown in this table as representative of post-TCRA conditions. This is because under the post-TCRA condition, only sediments at Beach Area A are accessible. These hazards were estimated using the same set of exposure parameters that were applied for calculating baseline estimated hazards, but with the EPCs described in Section 4 of this appendix.

Table F-18 presents the cumulative post-TCRA noncancer TEQ<sub>DF</sub> HI for each hypothetical exposure scenario evaluated. It presents the estimated baseline and background risks as well as the estimated reduction of hazard for each scenario. For the hypothetical recreational fisher and recreational visitor noncancer TEQ<sub>DF</sub> HIs for post-TCRA conditions are less than 1. For the hypothetical subsistence fisher, the post-TCRA exposure scenarios that assumed consumption of catfish in combination with direct contact to sediment (Scenarios 1A, 2A, and 3A) result in RME TEQ<sub>DF</sub> noncancer HIs of 6.

The greatest estimated hazard reductions are for hypothetical exposure scenarios that assume direct exposure to Beach Area E (Scenario 3A, 3B, and 3C). This is because the majority of

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TEQ<sub>DF</sub> exposure and hazard for these scenarios under baseline conditions was related to assumed direct contact rather than to assumed ingestion of fish or shellfish (Table F-17) and because exposure to sediment in this area is now completely restricted under the post-TCRA condition. For these scenarios, the estimated hazard reductions resulting from TCRA implementation range from 84 to 100 percent. For exposure scenarios that assume direct contact with sediments at Beach Area A, B/C, or D and consumption of catfish or clam from the adjacent FCA, the estimated hazard reduction of the TCRA implementation ranges from 65 to 86 percent.

## 5.2 Cancer Hazard

Table F-19 presents the post-TCRA cancer TEQ<sub>DF</sub> HQs for the individual pathways that make up the hypothetical exposure scenarios evaluated for the post-TCRA evaluation. Table F-20 presents the cancer TEQ<sub>DF</sub> HI as well as the measure of estimated hazard reduction attributed to the TCRA for each exposure scenario. The relative relationships between baseline, background, and post-TCRA cancer hazards are the same as those described for noncancer TEQ<sub>DF</sub> hazards above.

In all cases, the noncancer TEQ<sub>DF</sub> HI is 3.3 fold higher than the cancer TEQ<sub>DF</sub> HI. This is because the estimated noncancer hazard and cancer hazard rely on the same estimate of exposure and differ only in the toxicity criteria that were applied (i.e., for the noncancer evaluation a reference dose of 0.7 mg/kg-day was used, whereas for the cancer evaluation a cancer threshold TDI of 2.3 mg/kg-day was used) to estimate hazards.

Under the post-TCRA condition, the cancer TEQ<sub>DF</sub> HI is less than 1 for the hypothetical recreational fisher and recreational visitor for all of the scenarios evaluated. For the hypothetical subsistence fisher, only post-TCRA exposure scenarios that assume consumption of catfish in combination with direct contact to sediment result in a RME cancer TEQ<sub>DF</sub> HI greater than 1. The RME noncancer TEQ<sub>DF</sub> HI was estimated as 2 for these scenarios.

As was the case for the noncancer hazards summarized above, the greatest change in estimated hazards following implementation of the TCRA is for hypothetical exposure

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scenarios that assume direct exposure to Beach Area E (the hazard reductions ranged from 84 to 100 percent). For scenarios that assume direct contact with sediments at Beach Area A, B/C, or D and consumption of tissue from the adjacent FCA, the reduction of cancer hazard ranges from 65 to 86 percent.

### **5.3 Discussion of Uncertainty**

There are some uncertainties associated with the post-TCRA risk characterization presented here. The same uncertainties related to the exposure assumptions and toxicity evaluation for dioxins and furans that existed for estimating baseline hazards and risks also introduce uncertainty for this post-TCRA evaluation. These uncertainties were described in the main text of the BHHRA and are not repeated here.

The reliance on modeled concentrations of dioxins and furans in catfish fillet is also an uncertainty in this evaluation. Predictions of post-TCRA dioxin and furan concentrations in catfish tissue were completed using two different models. One model predicted TEQ<sub>DF</sub> for individual congeners, and only those congeners with significant relationships were modeled. The other was based on modeling TEQ<sub>DF</sub>. Both sets of predicted concentrations were used as the basis for the EPC for estimating hazards associated with exposure to catfish, and post-TCRA estimated risks using both sets of results are presented. The EPCs established from the congener-specific model were about 10 percent higher than those established from the model for TEQ<sub>DF</sub> (Table F-1). The impact that this difference in EPCs had on the resulting hazard estimates for individual exposure pathways, and on cumulative hypothetical exposure scenarios was minor (Tables F-17 through F-16); when considering the resulting hazard estimates, the choice of one approach over the other does not appear to introduce undue uncertainty into the risk characterization. However, the degree to which both approaches may overestimate post-TCRA catfish fillet concentrations, as discussed above in Section 4.1.6, is unknown and results in uncertainty in the degree of estimated post-TCRA hazard reduction for hypothetical fisher scenarios that assume ingestion of catfish.

In the absence of acceptable models or any other information on post-TCRA concentrations of dioxins and furan congener concentrations in edible crabs, post-TCRA conditions were represented by baseline data for edible crab for this evaluation. This assumption is

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conservative because it does not follow the conceptual framework of the regression models, i.e., that a reduction in concentrations of dioxins and furans in sediment will significantly reduce concentrations in tissue, because exposure of fish or shellfish to COPCs in sediments in the area addressed by the TCRA has been eliminated. Because the hazard estimates associated with assumed consumption of crabs from within USEPA's Preliminary Site Perimeter (i.e., when considered without direct contact with sediments) were relatively low (Tables F-17 and F-19), this assumption, while uncertain, does not affect confidence in the conclusion resulting from the final hazard characterization for hypothetical exposure scenarios that assume direct contact with sediments and consumption of crabs for the post-TCRA condition.

The post-TCRA evaluation of estimated noncancer and cancer hazards was completed only for dioxins and furans. This is because regression models were available for dioxins and furans but were not available for other risk-driving COPCs in tissue. While dioxins and furans are the largest contributor to the hazard estimates identified in the BHHRA, the impact of the TCRA on risk reduction for other COPCs is not addressed in this evaluation.

## 6 REFERENCES

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## TABLES

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**Table F-1**  
**Summary of Post-TCRA EPCs for TEQ<sub>DF</sub> (ng/kg)**

Medium	Basis	Number of Samples	CTE	RME
Sediment	Empirical data <sup>a</sup>		0.310	0.456
Soil	Empirical data <sup>b</sup>	6	4.43	7.67
Catfish — FCA 1	model, TEQ <sup>c</sup>	--	2.17	2.68
	model, congeners <sup>c</sup>	--	2.41	2.89
Catfish — FCA 2/3	model, TEQ <sup>c</sup>	--	2.03	2.50
	model, congeners <sup>c</sup>	--	2.27	2.71
Clam — FCA 2	Empirical data <sup>d</sup>	10	2.46	3.07
Crab — FCA 2/3	Empirical data <sup>e</sup>	20	0.164	0.286

**Notes**

-- = not applicable

CTE = central tendency exposure

EPC = exposure point concentration

FCA = fish collection area

RME = reasonable maximum exposure

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Only sediments in Beach Area A were accessible under the post-TCRA condition. Therefore, the EPC for sediments is based on the data points in that area.

b - The EPC for post-TCRA soil is calculated using only data from the soil locations that are accessible under the post-TCRA condition.

c - Post-TCRA catfish EPCs were calculated using modeled TEQ<sub>DF</sub> concentrations established as TEQ and as individual congeners.

d - Post-TCRA clam EPCs were calculated using the baseline clam dataset with clams sampled from transect 3 removed.

e - No data was available to calculate a reliable post-TCRA EPC for crabs. Therefore, the EPCs for crabs were conservatively assumed to be equal to baseline.

**Table F-2**  
**Results of Univariate Correlation (tau-b) for Individual Dioxin and Furan Congeners**  
**in Sediment and Crab Edible Tissue**

Analyte	tau-b	p-Value
2,3,7,8-TCDD	0.434	< 0.001
1,2,3,7,8-PeCDD	0.0401	0.447
1,2,3,4,7,8-HxCDD	0.0450	0.393
1,2,3,6,7,8-HxCDD	0.0517	0.329
1,2,3,7,8,9-HxCDD	-0.00204	0.970
1,2,3,4,6,7,8-HpCDD	0.168	0.00162
OCDD	0.149	0.00507
2,3,7,8-TCDF	0.465	< 0.001
1,2,3,7,8-PeCDF	0.255	< 0.001
2,3,4,7,8-PeCDF	0.282	< 0.001
1,2,3,4,7,8-HxCDF	0.141	0.00748
1,2,3,6,7,8-HxCDF	0.165	0.00181
1,2,3,7,8,9-HxCDF	0.0405	0.443
2,3,4,6,7,8-HxCDF	0.0677	0.199
1,2,3,4,6,7,8-HpCDF	0.0605	0.253
1,2,3,4,7,8,9-HpCDF	0.0638	0.227
OCDF	0.0149	0.780

**Table F-3**  
**Results of Univariate Correlation (tau-b) for Individual Dioxin and Furan Congeners in**  
**Sediment and Catfish Fillet**

Analyte	tau-b	p-Value
2,3,7,8-TCDD	0.449	< 0.001
1,2,3,7,8-PeCDD	0.144	0.0295
1,2,3,4,7,8-HxCDD	0.0603	0.362
1,2,3,6,7,8-HxCDD	-0.0627	0.345
1,2,3,7,8,9-HxCDD	-0.0405	0.542
1,2,3,4,6,7,8-HpCDD	0.0295	0.658
OCDD	0.0469	0.482
2,3,7,8-TCDF	0.299	< 0.001
1,2,3,7,8-PeCDF	0.0192	0.771
2,3,4,7,8-PeCDF	0.193	0.00360
1,2,3,4,7,8-HxCDF	0.0435	0.506
1,2,3,6,7,8-HxCDF	0.0245	0.711
1,2,3,7,8,9-HxCDF	-0.0782	0.233
2,3,4,6,7,8-HxCDF	0.00280	0.968
1,2,3,4,6,7,8-HpCDF	-0.0467	0.476
1,2,3,4,7,8,9-HpCDF	-0.0506	0.440
OCDF	-0.191	0.00402

Table F-4

## Results of MLR Analyses for Ah-R Active Dioxin and Furan Congeners in Crab Edible Tissue

Analyte	Model Terms	Coefficients <sup>a</sup>	Adjusted R <sup>2</sup>	p-Value
2,3,7,8-TCDD	Intercept	-0.58	0.491	< 0.001
	L	0.97 (ln)		
	Cs * L	0.29		
	TOC * L	-0.0013		
	Cs * S	-0.13 (Spring) 0.087 (Summer)	0.0620	0.00107
1,2,3,4,6,7,8-HpCDD	Intercept	0.34		
	Cs * TOC	8.6E-05		
OCDD	Intercept	1.2E+00	0.122	< 0.001
	Cs * L * S	0.0023 (Fall) 0.0074 (Spring) 0.0013 (Summer)		
2,3,7,8-TCDF	Intercept	-0.61	0.562	< 0.001
	L	1.1		
	S	-0.55 (Spring) 7.0 (Summer)		
	Cs * L	0.34		
	L * S	0.082 (Spring) -5.5 (Summer)		
	Cs * TOC * L	-0.0008		
1,2,3,7,8-PeCDF	Intercept	0.12	0.352	< 0.001
	Cs	-0.15		
	Cs * TOC * L	0.0016		
	Cs * TOC * S	-0.0027 (Spring) 0.0039 (Summer)		
	Cs * L * S	0.20 (Spring) -0.46 (Summer)		
2,3,4,7,8-PeCDF	Intercept	0.17	0.206	< 0.001
	Cs * L	0.071		
	Cs * S	-0.46 (Spring) 1.6 (Summer)		
	Cs * L * S	0.30 (Spring) -1.3 (Summer)		
1,2,3,4,7,8-HxCDF	Intercept	0.11	0.170	< 0.001
	Cs	-0.066		
	TOC * L	-0.00046		
	Cs * TOC * L	0.00061		
	Cs * TOC * S	-0.00022 (Spring) -0.00020 (Summer)		

**Table F-4**  
**Results of MLR Analyses for Ah-R Active Dioxin and Furan Congeners in Crab Edible Tissue**

Analyte	Model Terms	Coefficients <sup>a</sup>	Adjusted R <sup>2</sup>	p-Value
1,2,3,6,7,8-HxCDF	Intercept	0.13	0.0527	0.0167
	Cs	-0.15		
	Cs * TOC * L	0.0011		
	Cs * TOC * S	-0.00043 (Spring) -0.000023 (Summer)		

**Notes**

Only congeners with significant univariate correlations were evaluated

Ah-R = aryl hydrocarbon receptor

Cs = chemical concentration in sediment

L = lipid concentration

MLR = multiple linear regression

S = season

TOC = total organic carbon concentration

a - Variables were transformed prior to the multiple linear regression. These transformations are shown in Tables F-7 and F-9.

**Table F-5**  
**Results of MLR Analyses for Ah-R Active Dioxin and Furan Congeners in Catfish Fillets**

Analyte	Model Terms	Coefficients <sup>a</sup>	Adjusted R <sup>2</sup>	p-Value
TCDD	Intercept	1.3	0.570	< 0.001
	Cs	0.17		
	TOC	-0.011		
	TOC * L	0.0094		
	L * S	0.58 (Spring) -8.6 (Summer)		
	Cs * TOC * L	0.00054		
	Cs * L * S	-0.15 (Spring) 5.5 (Summer)		
TCDF	Intercept	0.28	0.467	< 0.001
	TOC	-0.0031		
	TOC * L	0.0031		
	Cs * TOC * L	0.00066		
	Cs * L * S	-0.060 (Spring) 0.097 (Summer)		

**Notes**

Only congeners with significant univariate correlations were evaluated

Ah-R = aryl hydrocarbon receptor

Cs = chemical concentration in sediment

L = lipid concentration

MLR = multiple linear regression

S = season

TOC = total organic carbon concentration

a - Variables were transformed prior to the MLR. These transformations are shown in Tables F-7 and F-10.

**Table F-6**  
**Percent Contribution of Each Dioxin and Furan Congener to Total**  
**Dioxin and Furan Concentration, by Tissue Type**

	Average Contribution to Total Dioxin and Furan Concentration (Percent) <sup>a</sup>
<b>Edible Crab</b>	
2,3,7,8-TCDD	13.9
1,2,3,4,6,7,8-HpCDD	4.67
OCDD	26.7
2,3,7,8-TCDF	26.3
1,2,3,7,8-PeCDF	1.51
2,3,4,7,8-PeCDF	1.98
1,2,3,4,7,8-HxCDF	1.28
1,2,3,6,7,8-HxCDF	1.08
Σ[D/F congeners]	77.4
<b>Catfish Fillet</b>	
2,3,7,8-TCDD	28.8
2,3,7,8-TCDF	2.94
Σ[D/F congeners]	31.7

**Notes**

a - Values from Table 5 and Table 7 (catfish fillet) of the *Technical Memorandum on Bioaccumulation Modeling* (Integral 2010).

**Table F-7**  
**Transformations of Sediment Data for Crab**

Code	Analyte	m	ShapiroP	NormR.sq	N	Mean	SD	Skewness	Kurtosis
sed_X2378TetDioxin_value	2,3,7,8-TCDD	ln	4.87E-05	0.957	160	1.90	1.23	0.356	-0.619
sed_X12378PenDioxin_value	1,2,3,7,8-PeCDD	ln	2.40E-06	0.941	160	0.655	0.334	0.599	-0.118
sed_X123478HexDioxin_value	1,2,3,4,7,8-HxCDD	ln	0.0182	0.982	160	1.04	0.475	-0.155	-0.669
sed_X123678HexDioxin_value	1,2,3,6,7,8-HxCDD	ln	0.000113	0.961	160	1.64	0.695	-0.127	-0.614
sed_X123789HexDioxin_value	1,2,3,7,8,9-HxCDD	sqrt	0.00335	0.975	160	2.22	0.573	-0.167	-0.835
sed_X1234678HepDioxin_value	1,2,3,4,6,7,8-HpCDD	sqrt	0.000736	0.969	160	11.3	5.11	0.366	-0.0786
sed_OctCIBzDioxin_value	OCDD	sqrt	0.0256	0.983	160	53.4	21.3	-0.154	-0.224
sed_X2378TetFuran_value	2,3,7,8-TCDF	ln	0.000344	0.967	160	2.65	1.54	0.117	-0.951
sed_X12378PenFuran_value	1,2,3,7,8-PeCDF	ln	3.92E-16	0.718	160	1.00	1.00	2.27	5.44
sed_X23478PenFuran_value	2,3,4,7,8-PeCDF	ln	8.43E-14	0.791	160	1.17	1.01	2.01	4.91
sed_X123478HexFuran_value	1,2,3,4,7,8-HxCDF	ln	1.30E-13	0.797	160	1.34	1.23	1.90	4.39
sed_X123678HexFuran_value	1,2,3,6,7,8-HxCDF	ln	5.66E-15	0.756	160	1.00	0.923	2.22	5.64
sed_X123789HexFuran_value	1,2,3,7,8,9-HxCDF	log10	5.44E-20	0.556	160	0.298	0.356	3.34	11.6
sed_X234678HexFuran_value	2,3,4,6,7,8-HxCDF	ln	1.70E-11	0.850	160	0.986	0.746	1.52	2.75
sed_X1234678HepFuran_value	1,2,3,4,6,7,8-HpCDF	ln	4.12E-06	0.943	160	2.88	1.36	0.547	1.37
sed_X1234789HepFuran_value	1,2,3,4,7,8,9-HpCDF	ln	7.20E-14	0.789	160	1.16	0.963	2.12	5.78
sed_OctCIBzFuran_value	OCDF	ln	1.38E-07	0.921	160	4.62	1.84	0.504	2.18
sed_Carbon_org_value	TOC	sqrt	0.00422	0.975	156	97.1	36.1	-0.188	-0.0415
sed_TEQ_value	TEQ (WHO-05)	ln	0.0226	0.983	160	2.67	1.22	0.122	-0.482

**Table F-8**  
**Transformations of Sediment Data for Catfish**

Analyte	m	ShapiroP	NormR.sq	N	Mean	SD	Skewness	Kurtosis
2,3,7,8-TCDD	ln	1.08E-10	0.863	154	2.00	1.604	1.46	3.09
1,2,3,7,8-PeCDD	log10	9.07E-18	0.641	154	0.273	0.306	3.00	10.3
1,2,3,4,7,8-HxCDD	sqrt	0.00108	0.971	154	1.71	0.360	0.0100	-0.749
1,2,3,6,7,8-HxCDD	sqrt	8.77E-06	0.946	154	2.31	0.749	0.472	0.156
1,2,3,7,8,9-HxCDD	sqrt	0.0101	0.980	154	2.19	0.601	-0.112	-0.598
1,2,3,4,6,7,8-HpCDD	sqrt	3.99E-05	0.953	154	11.2	4.49	0.322	0.849
OCDD	sqrt	0.0626	0.985	154	53.8	19.7	-0.0342	-0.00140
2,3,7,8-TCDF	ln	1.17E-08	0.902	154	2.73	1.82	1.06	1.90
1,2,3,7,8-PeCDF	ln	1.44E-17	0.650	154	0.942	1.24	2.60	6.72
2,3,4,7,8-PeCDF	ln	3.13E-15	0.738	154	1.18	1.14	2.23	5.33
1,2,3,4,7,8-HxCDF	ln	3.66E-15	0.741	154	1.41	1.37	2.19	5.16
1,2,3,6,7,8-HxCDF	ln	1.86E-16	0.694	154	1.00	1.06	2.46	6.32
1,2,3,7,8,9-HxCDF	ln	4.64E-19	0.584	154	0.611	0.925	2.82	7.49
2,3,4,6,7,8-HxCDF	ln	1.48E-11	0.843	154	0.947	0.810	1.55	2.91
1,2,3,4,6,7,8-HpCDF	ln	0.000913	0.968	154	2.88	1.24	-0.0746	0.317
1,2,3,4,7,8,9-HpCDF	ln	9.86E-13	0.814	154	1.097	0.967	1.72	3.07
OCDF	ln	4.19E-07	0.925	154	4.57	1.61	-0.283	1.82
TOC	sqrt	0.00360	0.973	154	95.8	32.2	-0.000902	0.302
TEQ (WHO-05)	ln	2.79E-09	0.890	154	2.70	1.52	1.26	3.03

**Table F-9  
Transformations for Crab Data**

Code	Analyte	Transform	ShapiroP	NormR.sq	N	Mean	SD	Skewness	Kurtosis
X2378TetDioxin_value	2,3,7,8-TCDD	ln	0.00423	0.977	160	1.14	0.623	0.0979	-0.926
X12378PenDioxin_value	1,2,3,7,8-PeCDD	ln	8.92E-12	0.838	160	0.187	0.120	2.15	8.83
X123478HexDioxin_value	1,2,3,4,7,8-HxCDD	ln	2.42E-16	0.703	160	0.123	0.0953	3.74	23.7
X123678HexDioxin_value	1,2,3,6,7,8-HxCDD	log10	4.89E-17	0.677	160	0.0852	0.0688	3.92	24.1
X123789HexDioxin_value	1,2,3,7,8,9-HxCDD	ln	6.16E-15	0.751	160	0.148	0.114	3.16	17.9
X1234678HepDioxin_value	1,2,3,4,6,7,8-HpCDD	ln	0.000157	0.960	160	0.524	0.285	0.772	1.37
OctCIDIbZDioxin_value	OCDD	ln	0.00424	0.973	160	1.53	0.664	0.507	0.986
X2378TetFuran_value	2,3,7,8-TCDF	ln	0.00227	0.974	160	1.54	0.809	-0.00551	-0.990
X12378PenFuran_value	1,2,3,7,8-PeCDF	ln	9.42E-15	0.759	160	0.219	0.190	2.56	9.41
X23478PenFuran_value	2,3,4,7,8-PeCDF	ln	1.05E-10	0.863	160	0.283	0.200	1.81	5.67
X123478HexFuran_value	1,2,3,4,7,8-HxCDF	log10	5.40E-19	0.598	160	0.0814	0.0925	3.81	18.9
X123678HexFuran_value	1,2,3,6,7,8-HxCDF	ln	2.89E-20	0.535	160	0.152	0.170	5.30	38.9
X123789HexFuran_value	1,2,3,7,8,9-HxCDF	ln	4.67E-21	0.494	160	0.163	0.203	6.01	49.3
X234678HexFuran_value	2,3,4,6,7,8-HxCDF	log10	8.70E-22	0.453	160	0.0611	0.0740	6.55	55.8
X1234678HepFuran_value	1,2,3,4,6,7,8-HpCDF	ln	7.02E-20	0.558	160	0.300	0.361	4.20	21.9
X1234789HepFuran_value	1,2,3,4,7,8,9-HpCDF	ln	1.12E-15	0.558	160	0.184	0.172	2.37	6.21
OctCIDIbZFuran_value	OCDF	ln	3.91E-15	0.733	160	0.993	0.996	2.33	6.65
Lipid_value	Lipid	sqrt	0.0385	0.749	154	1.29	0.122	0.0114	-0.303
TEQ_value	TEQ (WHO-05)	ln	0.048	0.985	160	1.35	0.632	0.0452	-0.823

**Table F-10**  
**Transformations for Fish Data**

Code	Analyte	Transform	ShapiroP	NormR.sq	N	Mean	SD	Skewness	Kurtosis
X2378TetDioxin_value	2,3,7,8-TCDD	ln	0.0702	0.986	154	1.57	0.759	0.00148	-0.811
X12378PenDioxin_value	1,2,3,7,8-PeCDD	ln	1.18E-14	0.750	154	0.236	0.205	3.09	16.6
X123478HexDioxin_value	1,2,3,4,7,8-HxCDD	ln	2.20E-21	0.453	154	0.149	0.182	7.53	74.8
X123678HexDioxin_value	1,2,3,6,7,8-HxCDD	ln	6.06E-10	0.872	154	0.395	0.275	1.88	9.16
X123789HexDioxin_value	1,2,3,7,8,9-HxCDD	ln	4.64E-20	0.524	154	0.191	0.194	6.64	62.8
X1234678HepDioxin_value	1,2,3,4,6,7,8-HpCDD	ln	1.23E-07	0.913	154	0.668	0.306	1.16	5.78
OctCIDIbZDioxin_value	OCDD	ln	0.151	0.987	154	1.30	0.550	0.211	-0.0872
X2378TetFuran_value	2,3,7,8-TCDF	ln	1.47E-13	0.786	154	0.341	0.332	2.32	7.86
X12378PenFuran_value	1,2,3,7,8-PeCDF	ln	2.53E-21	0.459	154	0.191	0.315	5.24	35.0
X23478PenFuran_value	2,3,4,7,8-PeCDF	ln	6.55E-16	0.706	154	0.361	0.315	3.84	26.4
X123478HexFuran_value	1,2,3,4,7,8-HxCDF	ln	3.99E-24	0.283	154	0.129	0.337	5.49	30.3
X123678HexFuran_value	1,2,3,6,7,8-HxCDF	ln	2.39E-18	0.615	154	0.263	0.395	2.70	7.68
X123789HexFuran_value	1,2,3,7,8,9-HxCDF	ln	3.39E-20	0.518	154	0.158	0.192	6.05	52.3
X234678HexFuran_value	2,3,4,6,7,8-HxCDF	ln	2.44E-22	0.396	154	0.139	0.192	7.72	74.9
X1234678HepFuran_value	1,2,3,4,6,7,8-HpCDF	ln	2.10E-20	0.511	154	0.238	0.285	4.60	25.3
X1234789HepFuran_value	1,2,3,4,7,8,9-HpCDF	ln	2.07E-20	0.508	154	0.194	0.246	5.54	42.0
OctCIDIbZFuran_value	OCDF	log10	1.67E-16	0.691	154	0.374	0.418	2.59	7.41
Lipid_value	Lipid	ln	0.0172	0.980	153	0.896	0.378	-0.0570	-0.898
TEQ_value	TEQ (WHO-05)	ln	0.212	0.989	154	1.69	0.74	0.0176	-0.697

**Table F-11**  
**Results of MLR Analyses for TEQ<sub>DF</sub> in Catfish Fillets**

<b>Analyte</b>	<b>Model Terms</b>	<b>Coefficients<sup>a</sup></b>	<b>Adjusted R<sup>2</sup></b>	<b>p-Value</b>
TEQ <sub>DF</sub>	sed_TEQ_value	0.185531114	0.538210297	5.30E-23
	sed_Carbon_org_value	-0.013317607		
	sed_Carbon_org_value:Lipid_value	0.012367782		
	(Intercept)	1.305228432		
	seasonSpring	0.522003879		
	sed_TEQ_value:seasonSpring	-0.112808542		
<b>Results of MLR Analyses for TEQ<sub>DF</sub> in Edible Crab</b>				
TEQ <sub>DF</sub>	sed_TEQ_value:Lipid_value	0.446401795	0.481806681	3.98E-20
	sed_TEQ_value:Lipid_value:sed_Carbon_org_value	-0.001407481		
	(Intercept)	0.410033112		
	sed_TEQ_value:seasonSpring	-0.654626072		
	sed_TEQ_value:Lipid_value:seasonSpring	0.405585028		

**Notes**

MLR = multiple linear regression

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Variables were transformed prior to the multiple linear regression. These transformations are shown in Tables F-7 through F-10. Coefficients must be used on the transformed data.

**Table F-12**  
**Estimated Concentrations (ng/kg) of Selected Dioxin/Furan Congeners and TEQ<sub>DF</sub> in Edible Crab and Catfish Fillet for Use in the Post-TCRA Risk Evaluation**

	TEF <sup>a</sup>	FCA 1			FCA 2/3		
		Estimated Concentration	95% Confidence Interval		Estimated Concentration	95% Confidence Interval	
		ng/kg ww	Lower	Upper	ng/kg ww	Lower	Upper
Edible Crab							
2,3,7,8-TCDD	1	0.74	0.36	1.51	0.72	0.35	1.48
1,2,3,4,6,7,8-HpCDD	0.01	1.47	1.38	1.56	1.47	1.39	1.56
OCDD	0.0003	3.23	2.52	4.14	3.24	2.54	4.14
2,3,7,8-TCDF	0.1	0.79	0.23	2.70	0.77	0.22	2.63
1,2,3,7,8-PeCDF	0.03	1.17	1.10	1.25	1.21	1.11	1.33
2,3,4,7,8-PeCDF	0.3	1.18	1.13	1.24	1.18	1.12	1.23
1,2,3,4,7,8-HxCDF	0.1	1.14	1.05	1.25	1.23	1.12	1.35
1,2,3,6,7,8-HxCDF	0.1	1.22	1.09	1.35	1.32	1.10	1.58
TEQ <sub>DF</sub> <sup>b</sup>		1.458	0.98	2.46	1.46	0.98	2.46
TEQ <sub>DF</sub> based prediction	--	1.76	1.49	2.08	1.72	1.46	2.04
Catfish Fillet							
2,3,7,8-TCDD	1	2.31	1.91	2.78	2.16	1.80	2.59
2,3,7,8-TCDF	0.1	1.07	0.98	1.17	1.06	0.97	1.16
TEQ <sub>DF</sub> <sup>b</sup>		2.41	2.01	2.89	2.27	1.90	2.71
TEQ <sub>DF</sub> based prediction	--	2.17	1.76	2.68	2.03	1.65	2.50

**Notes**

-- = Not applicable, no detected values

FCA = fish collection area

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEF = toxicity equivalency factor

ww = wet weight

a - Van den Berg et al. 2006 / EPA.

b - TEQ calculated from predicted congener concentrations.

**Table F-13**  
**Polygon Areas for Calculation of Post-TCRA SWACs**

<b>Sampling Location ID</b>	<b>Fractional Area<sup>a</sup></b>
<b>Fish Collection Area 1</b>	
SJSH003	0.1336%
SJSH004	0.3846%
SJSD001	0.1327%
SJSD002	0.6435%
SJSD003	0.2313%
SJSD004	0.2048%
SAMPLE 01-East	1.8161%
SAMPLE 02-Center	1.6756%
SAMPLE 03-West	3.2232%
SJNE001	4.7923%
SJNE002	6.2312%
SJNE003	8.3222%
SJNE004	7.1947%
SJNE005	3.7802%
SJNE006	8.9047%
SJNE007_Core	4.1314%
SJNE007_Grab	1.6732%
SJNE008_Grab	8.2760%
SJNE009	3.2789%
SJNE010	2.1179%
SJNE011	3.1753%
SJNE012_Core	1.2711%
SJNE012_Grab	1.2925%
SJNE013	7.0134%
SJNE014	2.3071%
SJNE015	2.2191%
SJNE016	5.1004%
SJNE017	2.2960%
SJNE018	1.4529%
SJNE019	0.8777%
SJSH001	2.2428%
SJSH002	0.3904%
SJSH005	0.7076%
SJSH012	0.3814%
SJSH014	0.4011%
SJSH056	0.3506%
SJSH057	0.2362%
SJSH058	1.1364%

**Table F-13**  
**Polygon Areas for Calculation of Post-TCRA SWACs**

<b>Sampling Location ID</b>	<b>Fractional Area<sup>a</sup></b>
<b>Fish Collection Areas 2 and 3</b>	
SJA3	0.1841%
SJA4	0.1862%
SJA5	0.4160%
SJB3	0.2196%
SJB4	0.1555%
SJB5	0.5504%
SJC3	0.1651%
SJC4	0.2222%
SJC5	0.5498%
SJD3	0.2144%
SJD4	0.1586%
SJD5	0.5244%
SJE3	0.2444%
SJE4	0.1852%
SJE5	0.2875%
SJNE020	0.8911%
SJNE021	1.2273%
SJNE023_Grab	0.7546%
SJNE024	1.4504%
SJNE025	1.2721%
SJNE026_Core	0.3876%
SJNE026_Grab	0.4799%
SJNE027	0.3068%
SJNE028_Grab	0.3045%
SJNE029_Core	0.7989%
SJNE029_Grab	0.6443%
SJNE030_Core	0.6167%
SJNE030_Grab	0.5019%
SJNE031	1.5592%
SJNE032_Core	0.5175%
SJNE032_Grab	0.2440%
SJNE033_Core	0.5374%
SJNE033_Grab	0.6434%
SJNE034	1.1192%
SJNE035_Core	0.8586%
SJNE035_Grab	0.6346%
SJNE036	0.6016%
SJNE037	1.3796%
SJNE038	5.8150%
SJNE039	1.5870%
SJNE040	1.6229%

**Table F-13**  
**Polygon Areas for Calculation of Post-TCRA SWACs**

<b>Sampling Location ID</b>	<b>Fractional Area<sup>a</sup></b>
SJNE041_Grab	1.3943%
SJNE042	1.4660%
SJNE043_Grab	1.4745%
SJNE044	1.4578%
SJNE045	1.3018%
SJNE046	1.5795%
SJNE047	2.4145%
SJNE048	1.8381%
SJNE049	1.4695%
SJNE050_Core	0.7525%
SJNE050_Grab	1.1421%
SJNE051	2.0907%
SJNE052	8.1781%
SJNE053	4.2325%
SJNE054	4.0648%
SJNE055	4.2476%
SJNE056	4.2062%
SJNE057	7.1074%
SJNE058	7.7125%
SJNE059	3.8799%
SJSH010	0.1125%
SJSH017	0.3705%
SJSH019	0.2245%
SJSH021	0.1666%
SJSH023	0.1484%
SJSH025	0.0614%
SJSH027	0.1024%
SJSH029	0.0878%
SJSH031	0.0759%
SJSH033	0.0783%
SJSH035	0.1984%
SJSH036	0.0160%
SJSH038	0.4813%
SJSH040	0.0731%
SJSH042	0.1623%
SJSH044	0.3494%
SJSH059	0.5986%

**Table F-13**  
**Polygon Areas for Calculation of Post-TCRA SWACs**

Sampling Location ID	Fractional Area <sup>a</sup>
SJSH060	0.4534%
SJSH061	0.8829%
1966 North Impoundment <sup>b</sup>	2.3264%

**Notes**

SWAC = surface area-weighted concentration

TCRA = time critical removal action

a - Fractional areas represent the area of a Thiessen polygon for a given sampling location divided by the sum of the areas of all Thiessen polygons in the fish collection area(s) considered.

b - The 1966 Northern Impoundment area represents a collection of 49 sampling locations that exist within the original perimeter of the TCRA.

**Table F-14**  
**Post-TCRA SWACs for Individual Dioxin and Furan Congeners<sup>a</sup>**

Sampling Location ID	2,3,7,8-TCDD	1,2,3,7,8-PcCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	2,3,7,8-TCDF	1,2,3,7,8-PeCDF
<b>Fish Collection Area 1</b>									
SJSH003	0.0019	0.0001	0.0002	0.0003	0.0009	0.0220	0.8015	0.0063	0.0003
SJSH004	0.0023	0.0001	0.0008	0.0011	0.0017	0.0373	1.3500	0.0078	0.0005
SJSD001	0.0166	0.0002	0.0009	0.0023	0.0031	0.0782	2.2298	0.0547	0.0015
SJSD002	0.0187	0.0003	0.0005	0.0027	0.0013	0.0882	2.6253	0.0641	0.0018
SJSD003	0.0177	0.0006	0.0009	0.0025	0.0028	0.0777	2.1904	0.0641	0.0019
SJSD004	0.0112	0.0004	0.0006	0.0016	0.0019	0.0487	1.0569	0.0340	0.0010
SAMPLE 01-East	0.1934	0.0084	0.0124	0.0350	0.0254	1.3294	25.6976	0.5167	0.0170
SAMPLE 02-Center	0.3452	0.0106	0.0132	0.0369	0.0457	1.3170	43.0634	0.8713	0.0245
SAMPLE 03-West	1.6438	0.0332	0.0322	0.0832	0.1060	3.4166	124.0929	5.5761	0.1209
SJNE001	0.0939	0.0076	0.0070	0.0068	0.0064	0.5990	21.5173	0.6422	0.0054
SJNE002	0.0087	0.0013	0.0020	0.0027	0.0024	0.0642	1.2088	0.0860	0.0007
SJNE003	0.1074	0.0028	0.0039	0.0053	0.0046	0.3953	10.6524	0.3479	0.0019
SJNE004	0.2511	0.0040	0.0085	0.0392	0.0399	1.4461	54.6795	1.2663	0.0377
SJNE005	0.0469	0.0016	0.0022	0.0125	0.0160	0.3969	15.3475	0.2147	0.0037
SJNE006	3.1167	0.0098	0.0189	0.0534	0.1710	4.2119	128.2283	13.2681	0.0926
SJNE007_Core	0.0863	0.0013	0.0009	0.0091	0.0010	0.3202	7.4366	0.2326	0.0015
SJNE007_Grab	0.5655	0.0053	0.0013	0.0025	0.0059	0.2326	7.9143	2.3090	0.0387
SJNE008_Grab	2.7145	0.0409	0.0204	0.1175	0.1556	4.1877	125.7951	11.4209	0.2756
SJNE009	0.0278	0.0010	0.0009	0.0012	0.0010	0.1410	3.7708	0.0882	0.0011
SJNE010	0.2817	0.0023	0.0032	0.0241	0.0092	0.6608	18.4254	1.0759	0.0126
SJNE011	0.3271	0.0026	0.0061	0.0486	0.0162	1.8035	38.7381	1.3082	0.0265
SJNE012_Core	0.0525	0.0007	0.0018	0.0041	0.0119	0.3305	9.7240	0.1373	0.0037
SJNE012_Grab	0.0140	0.0004	0.0004	0.0032	0.0033	0.0946	2.4428	0.0436	0.0003
SJNE013	0.0254	0.0016	0.0023	0.0034	0.0096	0.2904	7.9251	0.2041	0.0018
SJNE014	0.0519	0.0018	0.0020	0.0025	0.0021	0.3115	9.0440	0.3438	0.0023
SJNE015	0.0533	0.0014	0.0070	0.0083	0.0060	0.5459	17.0426	0.1789	0.0063
SJNE016	0.1581	0.0014	0.0017	0.0088	0.0170	0.6529	16.9843	0.4468	0.0132
SJNE017	0.2255	0.0021	0.0021	0.0173	0.0085	0.5166	15.2686	1.0562	0.0200
SJNE018	0.0478	0.0005	0.0007	0.0026	0.0008	0.1685	3.9955	0.1223	0.0016
SJNE019	0.0437	0.0002	0.0015	0.0051	0.0013	0.1510	3.8793	0.1080	0.0013
SJSH001	0.0068	0.0017	0.0007	0.0012	0.0035	0.0554	2.3326	0.0375	0.0004
SJSH002	0.0031	0.0001	0.0006	0.0009	0.0013	0.0299	0.9564	0.0107	0.0005
SJSH005	0.0024	0.0006	0.0014	0.0033	0.0066	0.0870	2.9293	0.0117	0.0001
SJSH012	0.0029	0.0005	0.0023	0.0053	0.0058	0.1556	2.5516	0.0088	0.0013
SJSH014	0.0002	0.0001	0.0004	0.0008	0.0006	0.0277	0.2759	0.0002	0.0001
SJSH056	0.0019	0.0001	0.0001	0.0007	0.0004	0.0212	0.8169	0.0074	0.0001
SJSH057	0.0036	0.0001	0.0003	0.0007	0.0010	0.0250	0.9284	0.0140	0.0005
SJSH058	0.0158	0.0010	0.0015	0.0014	0.0014	0.1421	4.7502	0.0841	0.0009
<b>Total SWAC</b>	<b>10.5871</b>	<b>0.1484</b>	<b>0.1637</b>	<b>0.5578</b>	<b>0.6993</b>	<b>24.4800</b>	<b>738.6695</b>	<b>42.2701</b>	<b>0.7218</b>

**Table F-14**  
**Post-TCRA SWACs for Individual Dioxin and Furan Congeners<sup>a</sup>**

Sampling Location ID	2,3,7,8-TCDD	1,2,3,7,8-PcCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	2,3,7,8-TCDF	1,2,3,7,8-PeCDF
<b>Fish Collection Areas 2 and 3</b>									
SJA3	0.0650	0.0008	0.0004	0.0010	0.0002	0.0291	0.9832	0.2173	0.0052
SJA4	0.1149	0.0014	0.0006	0.0018	0.0016	0.0596	2.1041	0.3780	0.0094
SJA5	0.1519	0.0020	0.0013	0.0040	0.0015	0.1211	4.0440	0.4951	0.0110
SJB3	0.1434	0.0021	0.0013	0.0038	0.0046	0.1126	3.9305	0.4831	0.0113
SJB4	0.0487	0.0003	0.0002	0.0004	0.0002	0.0313	1.0482	0.1586	0.0039
SJB5	0.0771	0.0014	0.0004	0.0038	0.0014	0.1354	5.6143	0.2526	0.0072
SJC3	0.0109	0.0001	0.0004	0.0010	0.0004	0.0320	1.1654	0.0357	0.0013
SJC4	0.0269	0.0002	0.0009	0.0021	0.0022	0.0804	2.9780	0.1016	0.0012
SJC5	0.0511	0.0013	0.0021	0.0057	0.0065	0.2111	8.2469	0.1869	0.0024
SJD3	0.0682	0.0010	0.0005	0.0039	0.0043	0.1235	3.9875	0.1726	0.0035
SJD4	0.0200	0.0002	0.0005	0.0014	0.0015	0.0503	1.7604	0.0672	0.0015
SJD5	0.0729	0.0015	0.0024	0.0070	0.0083	0.2491	8.4945	0.2255	0.0073
SJE3	0.0401	0.0001	0.0004	0.0006	0.0006	0.0379	1.1831	0.1618	0.0031
SJE4	0.0044	0.0002	0.0001	0.0034	0.0035	0.1078	3.3712	0.0222	0.0003
SJE5	0.0023	0.0002	0.0012	0.0035	0.0021	0.1673	6.4693	0.0060	0.0002
SJNE020	0.1123	0.0005	0.0018	0.0057	0.0105	0.4402	12.2979	0.3743	0.0127
SJNE021	0.0593	0.0009	0.0016	0.0112	0.0073	0.3486	9.9411	0.2209	0.0060
SJNE023_Grab	0.0689	0.0004	0.0005	0.0060	0.0069	0.1788	4.5125	0.2452	0.0019
SJNE024	0.0032	0.0010	0.0008	0.0011	0.0010	0.0361	1.1270	0.0231	0.0004
SJNE025	0.1959	0.0020	0.0030	0.0116	0.0393	0.8536	25.8242	0.6717	0.0077
SJNE026_Core	0.1872	0.0029	0.0017	0.0029	0.0041	0.1074	4.0698	0.7519	0.0175
SJNE026_Grab	0.0060	0.0002	0.0002	0.0003	0.0002	0.0068	0.4790	0.0411	0.0001
SJNE027	0.0303	0.0001	0.0001	0.0006	0.0002	0.0210	0.7425	0.1111	0.0027
SJNE028_Grab	0.0122	0.0002	0.0002	0.0010	0.0014	0.0390	1.2455	0.0372	0.0010
SJNE029_Core	0.0010	0.0007	0.0005	0.0009	0.0026	0.0605	2.9479	0.0011	0.0005
SJNE029_Grab	0.0112	0.0008	0.0009	0.0010	0.0009	0.0657	3.1311	0.0419	0.0006
SJNE030_Core	0.0011	0.0001	0.0010	0.0016	0.0029	0.0734	3.6568	0.0049	0.0001
SJNE030_Grab	0.0014	0.0001	0.0008	0.0015	0.0021	0.0627	2.0978	0.0128	0.0001
SJNE031	0.0120	0.0004	0.0009	0.0017	0.0026	0.1511	4.0071	0.1006	0.0033
SJNE032_Core	0.6986	0.0027	0.0005	0.0024	0.0016	0.0906	3.3637	2.9963	0.0564
SJNE032_Grab	0.2708	0.0020	0.0002	0.0028	0.0025	0.0976	2.9031	0.8831	0.0189
SJNE033_Core	0.0623	0.0023	0.0011	0.0054	0.0083	0.2101	7.1474	0.2338	0.0068
SJNE033_Grab	0.1126	0.0019	0.0007	0.0037	0.0088	0.2387	7.7854	0.3018	0.0078
SJNE034	0.0420	0.0004	0.0007	0.0022	0.0033	0.1858	7.8793	0.1142	0.0005
SJNE035_Core	0.0050	0.0029	0.0072	0.0052	0.0082	0.6130	36.8327	0.0129	0.0006
SJNE035_Grab	0.0297	0.0003	0.0006	0.0008	0.0007	0.0939	3.5537	0.0749	0.0005
SJNE036	0.0030	0.0002	0.0002	0.0003	0.0005	0.0274	0.8543	0.0202	0.0002
SJNE037	0.0734	0.0011	0.0010	0.0063	0.0131	0.3780	10.5123	0.2732	0.0090
SJNE038	0.1175	0.0068	0.0156	0.0192	0.0174	1.0525	35.0060	0.8839	0.0114
SJNE039	0.2857	0.0011	0.0016	0.0278	0.0267	0.9950	35.0717	0.9633	0.0309
SJNE040	0.2970	0.0009	0.0033	0.0091	0.0170	0.6832	23.5319	0.9315	0.0239
SJNE041_Grab	1.2730	0.0054	0.0014	0.0051	0.0056	0.4531	14.6400	3.5833	0.0941
SJNE042	0.1349	0.0007	0.0021	0.0080	0.0034	0.4442	16.7119	0.4750	0.0191
SJNE043_Grab	0.0230	0.0005	0.0005	0.0007	0.0006	0.0927	3.6567	0.0762	0.0004

**Table F-14**  
**Post-TCRA SWACs for Individual Dioxin and Furan Congeners<sup>a</sup>**

Sampling Location ID	2,3,7,8-TCDD	1,2,3,7,8-PcCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	2,3,7,8-TCDF	1,2,3,7,8-PeCDF
SJNE044	0.0223	0.0012	0.0020	0.0027	0.0058	0.3222	13.6597	0.1531	0.0012
SJNE045	0.0069	0.0002	0.0007	0.0010	0.0009	0.0751	2.4214	0.0540	0.0003
SJNE046	0.0742	0.0010	0.0013	0.0143	0.0161	0.4344	12.0834	0.2575	0.0034
SJNE047	0.1137	0.0017	0.0022	0.0136	0.0069	0.5143	17.4330	0.4056	0.0016
SJNE048	0.1577	0.0009	0.0035	0.0057	0.0208	0.5735	20.5866	0.5165	0.0104
SJNE049	0.1389	0.0013	0.0016	0.0160	0.0102	0.5555	20.7201	0.1528	0.0057
SJNE050_Core	0.1144	0.0022	0.0066	0.0141	0.0165	0.5636	25.9608	0.4146	0.0141
SJNE050_Grab	0.0015	0.0008	0.0005	0.0004	0.0004	0.0207	0.7538	0.0517	0.0009
SJNE051	0.0130	0.0021	0.0014	0.0017	0.0015	0.1767	6.3765	0.1029	0.0018
SJNE052	0.2413	0.0040	0.0258	0.0566	0.0594	1.9954	64.1160	0.7671	0.0276
SJNE053	0.2150	0.0015	0.0137	0.0389	0.0149	1.4814	58.8313	0.7111	0.0238
SJNE054	0.0086	0.0011	0.0134	0.1028	0.1264	2.4064	84.1413	0.0695	0.0009
SJNE055	0.3262	0.0059	0.0096	0.0295	0.0663	1.6863	62.4402	1.0407	0.0172
SJNE056	0.0116	0.0016	0.0011	0.0069	0.0031	0.2196	7.0243	0.0845	0.0019
SJNE057	0.0159	0.0019	0.0031	0.0163	0.0182	0.5217	18.6215	0.1208	0.0029
SJNE058	0.7581	0.0133	0.0256	0.0779	0.2244	6.5634	232.9180	2.6377	0.0094
SJNE059	0.1261	0.0023	0.0101	0.0354	0.0382	1.2532	43.0674	0.4152	0.0146
SJSH010	0.0101	0.0001	0.0001	0.0002	0.0004	0.0132	0.3320	0.0502	0.0012
SJSH017	0.0172	0.0002	0.0002	0.0011	0.0005	0.0323	0.8225	0.0641	0.0007
SJSH019	0.0087	0.0001	0.0003	0.0001	0.0006	0.0094	0.2224	0.0328	0.0009
SJSH021	0.0107	0.0001	0.0001	0.0005	0.0002	0.0128	0.3665	0.0420	0.0012
SJSH023	0.0009	0.0001	0.0001	0.0001	0.0001	0.0015	0.0341	0.0085	0.0001
SJSH025	0.0014	0.0000	0.0000	0.0003	0.0000	0.0060	0.0946	0.0060	0.0001
SJSH027	0.0001	0.0001	0.0002	0.0003	0.0002	0.0090	0.2428	0.0001	0.0001
SJSH029	0.0001	0.0001	0.0000	0.0000	0.0000	0.0032	0.0598	0.0012	0.0001
SJSH031	0.0001	0.0001	0.0000	0.0000	0.0000	0.0013	0.0668	0.0001	0.0001
SJSH033	0.0006	0.0001	0.0001	0.0001	0.0001	0.0032	0.0870	0.0071	0.0001
SJSH035	0.0139	0.0002	0.0001	0.0003	0.0006	0.0154	0.4445	0.0657	0.0015
SJSH036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.0345	0.0001	0.0000
SJSH038	0.0002	0.0001	0.0002	0.0011	0.0003	0.0424	0.8759	0.0012	0.0001
SJSH040	0.0000	0.0000	0.0000	0.0001	0.0001	0.0020	0.0283	0.0004	0.0002
SJSH042	0.0001	0.0001	0.0000	0.0000	0.0000	0.0047	0.2208	0.0001	0.0000
SJSH044	0.0002	0.0001	0.0001	0.0001	0.0001	0.0032	0.0992	0.0002	0.0001
SJSH059	0.0011	0.0002	0.0002	0.0003	0.0002	0.0126	0.4304	0.0111	0.0002
SJSH060	0.0010	0.0001	0.0001	0.0002	0.0002	0.0165	0.5531	0.0086	0.0001
SJSH061	0.0039	0.0002	0.0004	0.0005	0.0005	0.0471	1.6774	0.0289	0.0002
1966 North Impoundment <sup>b</sup>	0.0026	0.0006	0.0019	0.0030	0.0034	0.2745	8.1423	0.0143	0.0007
<b>Total SWAC</b>	<b>7.4464</b>	<b>0.0980</b>	<b>0.1899</b>	<b>0.6315</b>	<b>0.8766</b>	<b>29.5241</b>	<b>1,046.9011</b>	<b>25.7231</b>	<b>0.5493</b>

**Table F-14**  
**Post-TCRA SWACs for Individual Dioxin and Furan Congeners<sup>a</sup>**

Sampling Location ID	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF
<b>Fish Collection Area 1</b>								
SJSH003	0.0001	0.0004	0.0001	0.0000	0.0001	0.0017	0.0003	0.0168
SJSH004	0.0001	0.0006	0.0005	0.0001	0.0003	0.0035	0.0001	0.0269
SJSD001	0.0012	0.0029	0.0012	0.0001	0.0009	0.0108	0.0012	0.0925
SJSD002	0.0019	0.0036	0.0006	0.0001	0.0003	0.0125	0.0007	0.1023
SJSD003	0.0014	0.0038	0.0014	0.0001	0.0006	0.0112	0.0014	0.0985
SJSD004	0.0008	0.0017	0.0007	0.0000	0.0003	0.0069	0.0008	0.0707
SAMPLE 01-East	0.0247	0.0360	0.0161	0.0025	0.0158	0.2190	0.0215	1.4892
SAMPLE 02-Center	0.0265	0.0385	0.0176	0.0064	0.0133	0.1413	0.0186	1.8097
SAMPLE 03-West	0.1170	0.2005	0.0683	0.0254	0.0313	0.3546	0.0467	4.4158
SJNE001	0.0055	0.0086	0.0032	0.0067	0.0040	0.0748	0.0072	1.0016
SJNE002	0.0007	0.0042	0.0007	0.0012	0.0008	0.0016	0.0028	0.0785
SJNE003	0.0019	0.0185	0.0079	0.0030	0.0022	0.0471	0.0032	0.6192
SJNE004	0.0291	0.0440	0.0085	0.0091	0.0053	0.1561	0.0114	2.2663
SJNE005	0.0015	0.0122	0.0017	0.0025	0.0016	0.0529	0.0035	0.9715
SJNE006	0.1692	0.4791	0.1273	0.0086	0.0057	0.6661	0.0203	8.5307
SJNE007_Core	0.0015	0.0050	0.0056	0.0014	0.0014	0.0987	0.0092	1.3510
SJNE007_Grab	0.0318	0.0537	0.0078	0.0016	0.0012	0.0296	0.0085	0.1841
SJNE008_Grab	0.1796	0.9931	0.2698	0.0022	0.0545	1.0014	0.2168	5.5284
SJNE009	0.0011	0.0007	0.0007	0.0009	0.0008	0.0166	0.0011	0.1357
SJNE010	0.0181	0.0175	0.0045	0.0027	0.0023	0.0798	0.0136	0.9319
SJNE011	0.0196	0.0495	0.0145	0.0042	0.0037	0.1508	0.0056	2.0195
SJNE012_Core	0.0018	0.0071	0.0018	0.0007	0.0014	0.0400	0.0015	0.5911
SJNE012_Grab	0.0003	0.0028	0.0005	0.0004	0.0003	0.0083	0.0006	0.0635
SJNE013	0.0021	0.0022	0.0021	0.0026	0.0019	0.0123	0.0042	0.3696
SJNE014	0.0022	0.0061	0.0017	0.0023	0.0020	0.0392	0.0038	0.3945
SJNE015	0.0009	0.0043	0.0023	0.0018	0.0015	0.0353	0.0026	0.3839
SJNE016	0.0013	0.0272	0.0037	0.0019	0.0073	0.0887	0.0040	1.0507
SJNE017	0.0177	0.0126	0.0099	0.0019	0.0015	0.0652	0.0028	0.9069
SJNE018	0.0004	0.0084	0.0004	0.0005	0.0004	0.0278	0.0018	0.2717
SJNE019	0.0027	0.0062	0.0021	0.0003	0.0016	0.0202	0.0007	0.2405
SJSH001	0.0008	0.0001	0.0001	0.0002	0.0001	0.0031	0.0002	0.0505
SJSH002	0.0000	0.0007	0.0003	0.0001	0.0004	0.0030	0.0002	0.0289
SJSH005	0.0003	0.0002	0.0015	0.0001	0.0001	0.0031	0.0001	0.0241
SJSH012	0.0029	0.0055	0.0037	0.0002	0.0038	0.0831	0.0023	0.1652
SJSH014	0.0005	0.0001	0.0003	0.0002	0.0009	0.0067	0.0001	0.0208
SJSH056	0.0001	0.0003	0.0001	0.0001	0.0001	0.0017	0.0003	0.0189
SJSH057	0.0001	0.0006	0.0002	0.0002	0.0001	0.0024	0.0001	0.0288
SJSH058	0.0009	0.0010	0.0007	0.0016	0.0009	0.0128	0.0012	0.1864
<b>Total SWAC</b>	<b>0.6688</b>	<b>2.0595</b>	<b>0.5903</b>	<b>0.0934</b>	<b>0.1708</b>	<b>3.5901</b>	<b>0.4209</b>	<b>36.5365</b>

**Table F-14**  
**Post-TCRA SWACs for Individual Dioxin and Furan Congeners<sup>a</sup>**

Sampling Location ID	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF
<b>Fish Collection Areas 2 and 3</b>								
SJA3	0.0037	0.0078	0.0024	0.0001	0.0005	0.0052	0.0011	0.0335
SJA4	0.0073	0.0184	0.0023	0.0003	0.0003	0.0051	0.0010	0.0750
SJA5	0.0092	0.0188	0.0056	0.0002	0.0017	0.0166	0.0033	0.1340
SJB3	0.0085	0.0195	0.0056	0.0005	0.0018	0.0176	0.0036	0.1476
SJB4	0.0028	0.0058	0.0018	0.0000	0.0001	0.0050	0.0008	0.0502
SJB5	0.0055	0.0125	0.0038	0.0001	0.0006	0.0143	0.0023	0.1139
SJC3	0.0009	0.0021	0.0003	0.0001	0.0001	0.0038	0.0003	0.0348
SJC4	0.0023	0.0047	0.0007	0.0002	0.0007	0.0087	0.0012	0.0003
SJC5	0.0036	0.0095	0.0033	0.0003	0.0013	0.0227	0.0032	0.2161
SJD3	0.0034	0.0048	0.0016	0.0001	0.0008	0.0114	0.0013	0.1436
SJD4	0.0015	0.0024	0.0007	0.0001	0.0003	0.0056	0.0008	0.0655
SJD5	0.0051	0.0119	0.0040	0.0002	0.0010	0.0254	0.0030	0.3146
SJE3	0.0022	0.0036	0.0011	0.0001	0.0001	0.0029	0.0002	0.0187
SJE4	0.0001	0.0004	0.0005	0.0001	0.0001	0.0012	0.0002	0.0057
SJE5	0.0002	0.0003	0.0002	0.0003	0.0003	0.0014	0.0003	0.0070
SJNE020	0.0069	0.0197	0.0075	0.0008	0.0016	0.0612	0.0076	0.9803
SJNE021	0.0012	0.0054	0.0049	0.0012	0.0010	0.0434	0.0018	0.7045
SJNE023_Grab	0.0036	0.0093	0.0026	0.0008	0.0005	0.0137	0.0009	0.1404
SJNE024	0.0004	0.0004	0.0005	0.0008	0.0005	0.0059	0.0010	0.0183
SJNE025	0.0181	0.0346	0.0127	0.0043	0.0033	0.1088	0.0074	1.2403
SJNE026_Core	0.0122	0.0189	0.0050	0.0002	0.0020	0.0145	0.0029	0.1461
SJNE026_Grab	0.0001	0.0010	0.0002	0.0004	0.0003	0.0028	0.0005	0.0118
SJNE027	0.0019	0.0038	0.0009	0.0001	0.0001	0.0026	0.0001	0.0196
SJNE028_Grab	0.0002	0.0007	0.0001	0.0001	0.0001	0.0014	0.0001	0.0138
SJNE029_Core	0.0005	0.0002	0.0002	0.0003	0.0002	0.0002	0.0003	0.0004
SJNE029_Grab	0.0005	0.0007	0.0007	0.0008	0.0008	0.0069	0.0008	0.0534
SJNE030_Core	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0061
SJNE030_Grab	0.0001	0.0001	0.0001	0.0001	0.0001	0.0012	0.0002	0.0124
SJNE031	0.0008	0.0063	0.0024	0.0006	0.0005	0.0193	0.0009	0.1746
SJNE032_Core	0.0402	0.0493	0.0115	0.0008	0.0025	0.0184	0.0049	0.0968
SJNE032_Grab	0.0142	0.0307	0.0039	0.0002	0.0010	0.0214	0.0038	0.1110
SJNE033_Core	0.0020	0.0082	0.0011	0.0004	0.0003	0.0173	0.0005	0.1274
SJNE033_Grab	0.0067	0.0132	0.0019	0.0012	0.0014	0.0365	0.0014	0.5135
SJNE034	0.0004	0.0026	0.0006	0.0011	0.0007	0.0050	0.0012	0.0834
SJNE035_Core	0.0010	0.0012	0.0008	0.0003	0.0002	0.0033	0.0003	0.0170
SJNE035_Grab	0.0005	0.0054	0.0006	0.0007	0.0005	0.0102	0.0009	0.1168
SJNE036	0.0002	0.0010	0.0005	0.0001	0.0003	0.0026	0.0002	0.0267
SJNE037	0.0055	0.0123	0.0024	0.0015	0.0020	0.0430	0.0020	0.5491
SJNE038	0.0113	0.0611	0.0206	0.0398	0.0202	0.0439	0.0512	0.3315
SJNE039	0.0105	0.0570	0.0168	0.0046	0.0042	0.1162	0.0049	1.0744
SJNE040	0.0188	0.0696	0.0076	0.0021	0.0027	0.0760	0.0027	0.6492
SJNE041_Grab	0.0664	0.1813	0.0468	0.0011	0.0039	0.0696	0.0057	0.2649
SJNE042	0.0106	0.0204	0.0026	0.0021	0.0014	0.0346	0.0024	0.5219
SJNE043_Grab	0.0004	0.0046	0.0006	0.0009	0.0006	0.0034	0.0010	0.0833

**Table F-14**  
**Post-TCRA SWACs for Individual Dioxin and Furan Congeners<sup>a</sup>**

Sampling Location ID	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF
SJNE044	0.0011	0.0044	0.0023	0.0037	0.0026	0.0284	0.0033	0.2959
SJNE045	0.0003	0.0030	0.0017	0.0003	0.0002	0.0083	0.0003	0.0784
SJNE046	0.0057	0.0054	0.0060	0.0011	0.0009	0.0543	0.0023	0.7171
SJNE047	0.0016	0.0146	0.0098	0.0032	0.0023	0.0681	0.0046	0.5288
SJNE048	0.0055	0.0117	0.0049	0.0019	0.0012	0.0555	0.0036	0.5845
SJNE049	0.0094	0.0187	0.0084	0.0012	0.0055	0.0551	0.0024	0.6245
SJNE050_Core	0.0096	0.0238	0.0066	0.0019	0.0023	0.0553	0.0079	0.6878
SJNE050_Grab	0.0009	0.0004	0.0004	0.0006	0.0004	0.0006	0.0006	0.0095
SJNE051	0.0018	0.0068	0.0014	0.0017	0.0017	0.0228	0.0020	0.1702
SJNE052	0.0222	0.0454	0.0089	0.0052	0.0045	0.1595	0.0250	1.4230
SJNE053	0.0091	0.0466	0.0077	0.0047	0.0047	0.1464	0.0074	1.6507
SJNE054	0.0009	0.0026	0.0025	0.0043	0.0026	0.0080	0.0026	0.1488
SJNE055	0.0059	0.0573	0.0280	0.0079	0.0095	0.2001	0.0089	2.0304
SJNE056	0.0017	0.0014	0.0013	0.0018	0.0016	0.0187	0.0018	0.1342
SJNE057	0.0028	0.0075	0.0023	0.0032	0.0028	0.0316	0.0032	0.2466
SJNE058	0.0089	0.1381	0.0246	0.0160	0.0139	0.5923	0.0169	6.4400
SJNE059	0.0020	0.0127	0.0104	0.0031	0.0052	0.1214	0.0123	0.8963
SJSH010	0.0010	0.0014	0.0004	0.0001	0.0003	0.0015	0.0003	0.0063
SJSH017	0.0005	0.0010	0.0006	0.0001	0.0001	0.0034	0.0001	0.0129
SJSH019	0.0003	0.0013	0.0001	0.0000	0.0000	0.0005	0.0001	0.0013
SJSH021	0.0008	0.0015	0.0004	0.0000	0.0000	0.0009	0.0001	0.0012
SJSH023	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
SJSH025	0.0001	0.0002	0.0001	0.0000	0.0001	0.0009	0.0000	0.0029
SJSH027	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
SJSH029	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0008
SJSH031	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
SJSH033	0.0001	0.0002	0.0000	0.0001	0.0001	0.0003	0.0001	0.0022
SJSH035	0.0007	0.0019	0.0005	0.0001	0.0001	0.0013	0.0003	0.0056
SJSH036	0.0000	0.0001	0.0000	0.0000	0.0000	0.0003	0.0000	0.0014
SJSH038	0.0002	0.0016	0.0003	0.0002	0.0002	0.0088	0.0013	0.0417
SJSH040	0.0000	0.0006	0.0002	0.0000	0.0001	0.0014	0.0003	0.0082
SJSH042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0004
SJSH044	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0009
SJSH059	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0003	0.0106
SJSH060	0.0001	0.0001	0.0001	0.0001	0.0001	0.0011	0.0003	0.0135
SJSH061	0.0002	0.0017	0.0002	0.0003	0.0002	0.0038	0.0005	0.0383
1966 North Impoundment <sup>b</sup>	0.0006	0.0016	0.0013	0.0011	0.0020	0.0147	0.0008	0.1219
<b>Total SWAC</b>	<b>0.3861</b>	<b>1.1554</b>	<b>0.3224</b>	<b>0.1351</b>	<b>0.1280</b>	<b>2.5972</b>	<b>0.2405</b>	<b>26.3862</b>

**Notes**

SWAC = surface area-weighted concentration

TCRA = time critical removal action

a - For each congener, SWAC values are equal to the sum of the individual sampling site values.

b - The 1966 North Impoundment area represents a collection of 49 sampling locations that exist within the original perimeter of the TCRA.

Table F-15

## Summary Statistics for Dioxins and Furans in Edible Blue Crab Tissue by FCA, Wet Weight

	Mean <sup>a</sup>		
	FCA 1	FCA 2	FCA 3
<b>Blue Crab - Edible</b>			
<b>Dioxins and Furans (ng/kg - ww)</b>			
2,3,7,8-TCDD	0.523	0.126	0.0608
1,2,3,7,8-PeCDD	0.0402	0.028	0.0333
1,2,3,4,7,8-HxCDD	0.0248	0.023	0.025
1,2,3,6,7,8-HxCDD	0.0534	0.03	0.0311
1,2,3,7,8,9-HxCDD	0.0435	0.0256	0.027
1,2,3,4,6,7,8-HpCDD	0.134	0.0347	0.0282
OCDD	0.645	0.329	0.0962
2,3,7,8-TCDF	1.39	0.504	0.238
1,2,3,7,8-PeCDF	0.0289	0.0258	0.0309
2,3,4,7,8-PeCDF	0.0276	0.0257	0.0295
1,2,3,4,7,8-HxCDF	0.0376	0.0185	0.0208
1,2,3,6,7,8-HxCDF	0.0442	0.0181	0.0197
1,2,3,7,8,9-HxCDF	0.0276	0.0244	0.0257
2,3,4,6,7,8-HxCDF	0.0315	0.0202	0.0212
1,2,3,4,6,7,8-HpCDF	0.0319	0.0195	0.0265
1,2,3,4,7,8,9-HpCDF	0.0377	0.0282	0.0387
OCDF	0.15	0.042	0.0577
TEQ <sub>DF</sub> <sup>b</sup>	0.739	0.23	0.146

**Notes**

FCA = fish collection area

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

ww = wet weight

a - Mean calculations include detected and nondetected values. Nondetected values were set at one-half the detection limit.

b - Toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors with nondetects set at one-half the detection limit.

**Table F-16**  
**Summary Statistics for Dioxins and Furans in Fillet Hardhead Catfish Tissue by FCA,**  
**Wet Weight**

	Mean <sup>a</sup>		
	FCA 1	FCA 2	FCA 3
<b>Catfish - Fillet</b>			
<b>Dioxins and Furans (ng/kg - ww)</b>			
2,3,7,8-TCDD	2.77	3.6	2.97
1,2,3,7,8-PeCDD	0.063	0.0978	0.130
1,2,3,4,7,8-HxCDD	0.0242	0.0395	0.0696
1,2,3,6,7,8-HxCDD	0.2	0.256	0.476
1,2,3,7,8,9-HxCDD	0.0554	0.0409	0.145
1,2,3,4,6,7,8-HpCDD	0.222	0.239	0.801
OCDD	0.436	0.558	1.02
2,3,7,8-TCDF	0.319	0.779	0.579
1,2,3,7,8-PeCDF	0.0229	0.0291	0.0269
2,3,4,7,8-PeCDF	0.111	0.157	0.158
1,2,3,4,7,8-HxCDF	0.0146	0.0219	0.0236
1,2,3,6,7,8-HxCDF	0.0139	0.0173	0.0166
1,2,3,7,8,9-HxCDF	0.0185	0.0216	0.0199
2,3,4,6,7,8-HxCDF	0.0154	0.0201	0.0181
1,2,3,4,6,7,8-HpCDF	0.0182	0.0191	0.0197
1,2,3,4,7,8,9-HpCDF	0.0272	0.0265	0.0259
OCDF	0.0494	0.0357	0.0573
TEQ <sub>DF</sub> <sup>b</sup>	2.94	3.87	3.29

**Notes**

FCA = fish collection area

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

ww = wet weight

a - Mean and median calculations include detected and nondetected values. Nondetected values were set at one-half the detection limit.

b - Toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors with nondetects set at one-half the detection limit.

**Table F-17**  
**Post-TCRA TEQ<sub>DF</sub> Noncancer Hazard Quotients for Individual Pathways**

Post-TCRA Pathway	Noncancer TEQ <sub>DF</sub> HQ <sup>a</sup>	
	RME	CTE
<b>Direct Contact</b>		
Hypothetical Recreational Fisher (Beach Area A sediment)	2E-03	9E-05
Hypothetical Subsistence Fisher (Beach Area A sediment)	4E-03	--
Hypothetical Recreational Visitor (Beach Area A sediment)	2E-03	2E-04
Hypothetical Recreational Visitor (post-TCRA soil)	6E-03	6E-05
<b>Tissue Ingestion</b>		
Hypothetical Recreational Fisher (post-TCRA catfish FCA 2/3)	7E-01 (7E-01)	8E-02(9E-02)
Hypothetical Recreational Fisher (post-TCRA catfish FCA 1)	7E-01 (7E-01)	8E-02(9E-02)
Hypothetical Subsistence Fisher (post-TCRA catfish FCA 2/3)	6E+00 (6E+00)	--
Hypothetical Subsistence Fisher (post-TCRA catfish FCA 1)	6E+00 (6E+00)	--
Hypothetical Recreational Fisher (post-TCRA clam FCA 2)	3E-02	4E-03
Hypothetical Subsistence Fisher (post-TCRA clam FCA 2)	5E-01	--
Hypothetical Subsistence Fisher (post-TCRA crab FCA 2/3)	4E-02	--
Hypothetical Recreational Fisher (post-TCRA crab FCA 2/3)	3E-03	3E-04

**Notes**

-- = not applicable; in line with the Exposure Assessment Memorandum, CTE hazards were not calculated for hypothetical subsistence fishers

CTE= central tendency exposure

HQ = hazard quotient

RME = reasonable maximum exposure

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - For scenarios that include ingestion of catfish post-TCRA, hazards calculated using the TEQ-derived exposure point concentration are shown first, while those calculated based on exposure point concentration derived for only a subset of congeners, are shown in parenthesis.

**Table F-18**  
**Post-TCRA TEQ<sub>DF</sub> Noncancer Hazard Index and Hazard Reduction**

Baseline Scenario with TEQ <sub>DF</sub> HQ> 1	Corresponding Post-TCRA Scenario	Noncancer TEQ <sub>DF</sub> HI						Hazard Reduction <sup>b</sup>	
		Post-TCRA <sup>a</sup>		Baseline		Background			
		RME	CTE	RME	CTE	RME	CTE	RME	CTE
Hypothetical Recreational Fisher (Direct Contact/Tissue Ingestion)									
3A - (Beach Area E/Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	7E-01 (7E-01)	8E-02 (9E-02)	4E+01	4E-01	4E-01	2E-02	99%	84%
3B - (Beach Area E/ Clam FCA 2)	(Beach Area A/ post-TCRA clam FCA 2)	4E-02	4E-03	4E+01	3E-01	7E-03	8E-04	100%	99%
3C - (Beach Area E/ Crab FCA 2/3)	(Beach Area A/ Crab FCA 2/3)	5E-03	4E-04	4E+01	3E-01	4E-03	3E-04	100%	100%
Hypothetical Subsistence Fisher (Direct Contact/Tissue Ingestion)									
1A - (Beach Area A/ Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	6E+00 (6E+00)	--	9E+00	--	4E+00	--	65%	--
2A - (Beach Area AB/C/ Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	6E+00 (6E+00)	--	9E+00	--	4E+00	--	65%	--
3A - (Beach Area AE/ Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	6E+00 (6E+00)	--	1E+02	--	4E+00	--	98%	--
4A - (Beach Area D/Catfish FCA 1)	None <sup>c</sup>	--	--	--	--	--	--	--	--
2B - (Beach Area B/C/ Clam FCA 2)	(Beach Area A/ post-TCRA clam FCA 2)	5E-01	--	3E+00	--	8E-02	--	86%	--
3B - (Beach Area E/ Clam FCA 2)	(Beach Area A/ post-TCRA clam FCA 2)	5E-01	--	3E+00	--	8E-02	--	86%	--
3C - (Beach Area E/ Crab FCA 2/3)	(Beach Area A/ Crab FCA 2/3)	5E-02	--	1E+02	--	3E-02	--	100%	--
Hypothetical Recreational Visitor (Direct Contact)									
3 - (Beach Area E and soils North of I-10)	(Beach Area A and post-TCRA soils North of I-10)	8E-03	2E-04	6E+01	5E-01	9E-03	3E-04	100%	100%

**Notes**

-- = not applicable; in line with the Exposure Assessment Memorandum, CTE hazards were not calculated for hypothetical subsistence fishers

CTE= central tendency exposure

EPC = exposure point concentration

FCA = fish collection area

HI = hazard index

HQ = hazard quotient

RME = reasonable maximum exposure

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - For scenarios that include ingestion of catfish, the post-TCRA hazard calculated using the TEQ-derived EPC is shown first, and that calculated based on the EPC derived for only a subset of congeners is shown second, in parentheses.

b -Hazard reduction is calculated as 1-((post-TCRA HI-background HI)/(baseline HI-background HI)).

c - Only Beach Area A is accessible under post-TCRA conditions. Because FCA 1 is not adjacent to this area, consumption of catfish from FCA 1 in combination with direct exposure to sediments is not a possible post-TCRA condition.

**Table F-19**  
**Post-TCRA TEQ<sub>DF</sub> Cancer Hazard Quotients for Individual Pathways**

Post-TCRA Pathway	Noncancer TEQ <sub>DF</sub> HQ <sup>a</sup>	
	RME	CTE
<b>Direct Contact</b>		
Hypothetical Recreational Fisher (Beach Area A sediment)	5E-04	3E-05
Hypothetical Subsistence Fisher (Beach Area A sediment)	1E-03	--
Hypothetical Recreational Visitor (Beach Area A sediment)	6E-04	5E-05
Hypothetical Recreational Visitor (post-TCRA soil)	2E-03	2E-05
<b>Tissue Ingestion</b>		
Hypothetical Recreational Fisher (post-TCRA catfish FCA 2/3)	2E-01 (2E-01)	2E-02 (3E-02)
Hypothetical Recreational Fisher (post-TCRA catfish FCA 1)	2E-01 (2E-01)	2E-02 (3E-02)
Hypothetical Subsistence Fisher (post-TCRA catfish FCA 2/3)	2E+00 (2E+00)	--
Hypothetical Subsistence Fisher (post-TCRA catfish FCA 1)	2E+00 (2E+00)	--
Hypothetical Recreational Fisher (post-TCRA clam FCA 2)	1E-02	1E-03
Hypothetical Subsistence Fisher (post-TCRA clam FCA 2)	1E-01	--
Hypothetical Subsistence Fisher (post-TCRA crab FCA 2/3)	1E-02	--
Hypothetical Recreational Fisher (post-TCRA crab FCA 2/3)	1E-03	9E-05

**Notes**

-- = not applicable; in line with the Exposure Assessment Memorandum, CTE hazards were not calculated for hypothetical subsistence fishers

CTE= central tendency exposure

EPC = exposure point concentration

FCA = fish collection area

HQ = hazard quotient

RME = reasonable maximum exposure

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - For scenarios that include ingestion of catfish, the post-TCRA hazard calculated using the TEQ-derived EPC is shown first, and that calculated based on the EPC derived for only a subset of congeners is shown second, in parentheses.

**Table F-20**  
**Post-TCRA TEQ<sub>DF</sub> Cancer Hazard Index and Hazard Reduction**

Baseline Scenario with TEQ <sub>DF</sub> HQ> 1	Corresponding Post-TCRA Scenario	Cancer TEQ <sub>DF</sub> HI						Hazard Reduction <sup>b</sup>	
		Post-TCRA <sup>a</sup>		Baseline		Background			
		RME	CTE	RME	CTE	RME	CTE	RME	CTE
Hypothetical Recreational Fisher (Direct Contact/Tissue Ingestion)									
3A - (Beach Area E/Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	2E-01 (2E-01)	2E-02 (3E-02)	1E+01	1E-01	1E-01	6E-03	99%	84%
3B - (Beach Area E/Clam FCA 2)	(Beach Area A/post-TCRA clam FCA 2)	1E-02	1E-03	1E+01	8E-02	2E-03	2E-04	100%	99%
3C - (Beach Area E/Crab FCA 2/3)	(Beach Area A/Crab FCA 2/3)	1E-03	1E-04	1E+01	8E-02	1E-03	1E-04	100%	100%
Hypothetical Subsistence Fisher (Direct Contact/Tissue Ingestion)									
1A - ( Beach Area A/Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	2E+00 (2E+00)	--	3E+00	--	1E+00	--	65%	--
2A - (Beach Area B/C/Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	2E+00 (2E+00)	--	3E+00	--	1E+00	--	65%	--
3A - (Beach Area E/Catfish FCA 2/3)	(Beach Area A/post-TCRA catfish FCA 2/3)	2E+00 (2E+00)	--	4E+01	--	1E+00	--	98%	--
4A - ( Beach Area D/Catfish FCA 1)	None <sup>c</sup>	--	--	--	--	--	--	--	--
2B -(Beach Area B/C/Clam FCA 2)	(Beach Area A/post-TCRA clam FCA 2)	1E-01	--	9E-01	--	2E-02	--	86%	--
3B - (Beach Area E/Clam FCA 2)	(Beach Area A/post-TCRA clam FCA 2)	1E-01	--	9E-01	--	2E-02	--	86%	--
3C - (Beach Area E/Crab FCA 2/3)	(Beach Area A/Crab FCA 2/3)	1E-02	--	4E+01	--	1E-02	--	100%	--
Hypothetical Recreational Visitor (Direct Contact)									
3 - (Beach Area E and soils North of I-10)	(Beach Area A and post-TCRA soils North of I-10)	2E-03	7E-05	2E+01	2E-01	3E-03	8E-05	100%	--

**Notes**

-- = not applicable; in line with the Exposure Assessment Memorandum, CTE hazards were not calculated for hypothetical subsistence fishers

CTE= central tendency exposure

EPC = exposure point concentration

FCA = fish collection area

HI = hazard index

HQ = hazard quotient

RME = reasonable maximum exposure

TCRA = time critical removal action

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - For scenarios that include ingestion of catfish, the post-TCRA hazard calculated using the TEQ-derived EPC is shown first, and that calculated based on the EPC derived for only a subset of congeners is shown second, in parentheses.

b - Hazard reduction is calculated as 1-((post-TCRA HI-background HI)/(baseline HI-background HI)).

c - Only Beach Area A is accessible under post-TCRA conditions. Because FCA 1 is not adjacent to this area, consumption of catfish from FCA 1 in combination with direct exposure to sediments is not a possible post-TCRA condition.

## FIGURES

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**Note**  
TCRA = time-critical removal action



**Figure F-2**  
Fencing Introduced as Part of the Time-Critical Removal Action and by the Coastal Water Authority Draft Baseline Human Health Risk Assessment San Jacinto River Waste Pits Superfund Site



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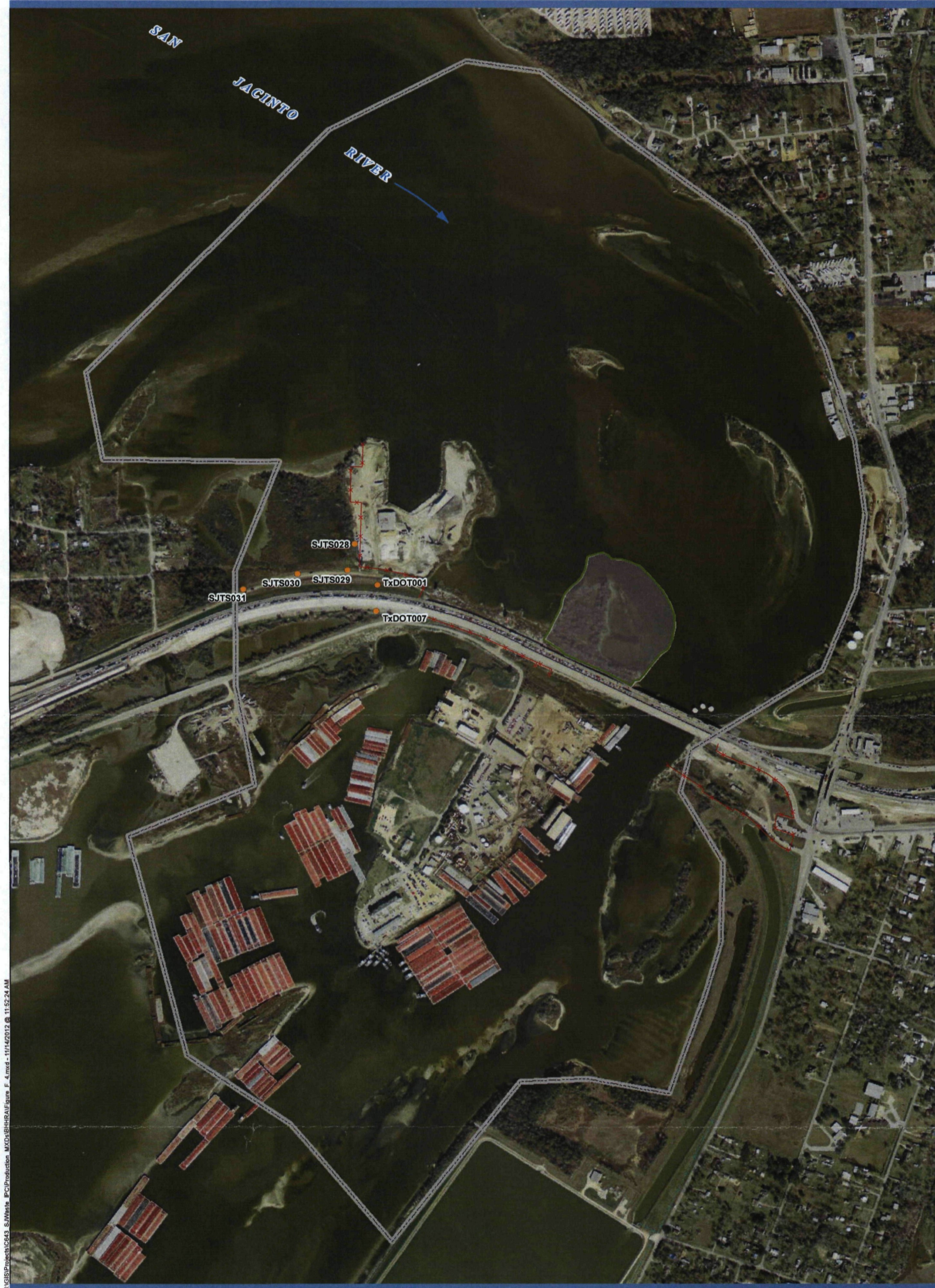




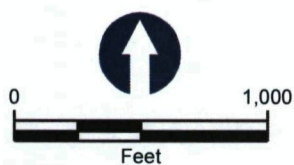

- Surface Sediment Sampling Locations
- Exposure Unit Designation
- TCRA Fence Line
- Coastal Water Authority Fence Line
- 0 Contour (NAVD 88)<sup>a</sup>
- Original 1966 Perimeter of the Impoundments North of I-10
- Approximate TCRA Footprint
- USEPA's Preliminary Site Perimeter

**Figure F-3**  
 Exposure Unit for Sediment, Area North of I-10 and  
 Aquatic Environment, Post-TCRA  
 Draft Baseline Human Health Risk Assessment  
 San Jacinto River Waste Pits Superfund Site

Note: <sup>a</sup> Tidal conditions under which this contour was measured are unknown.

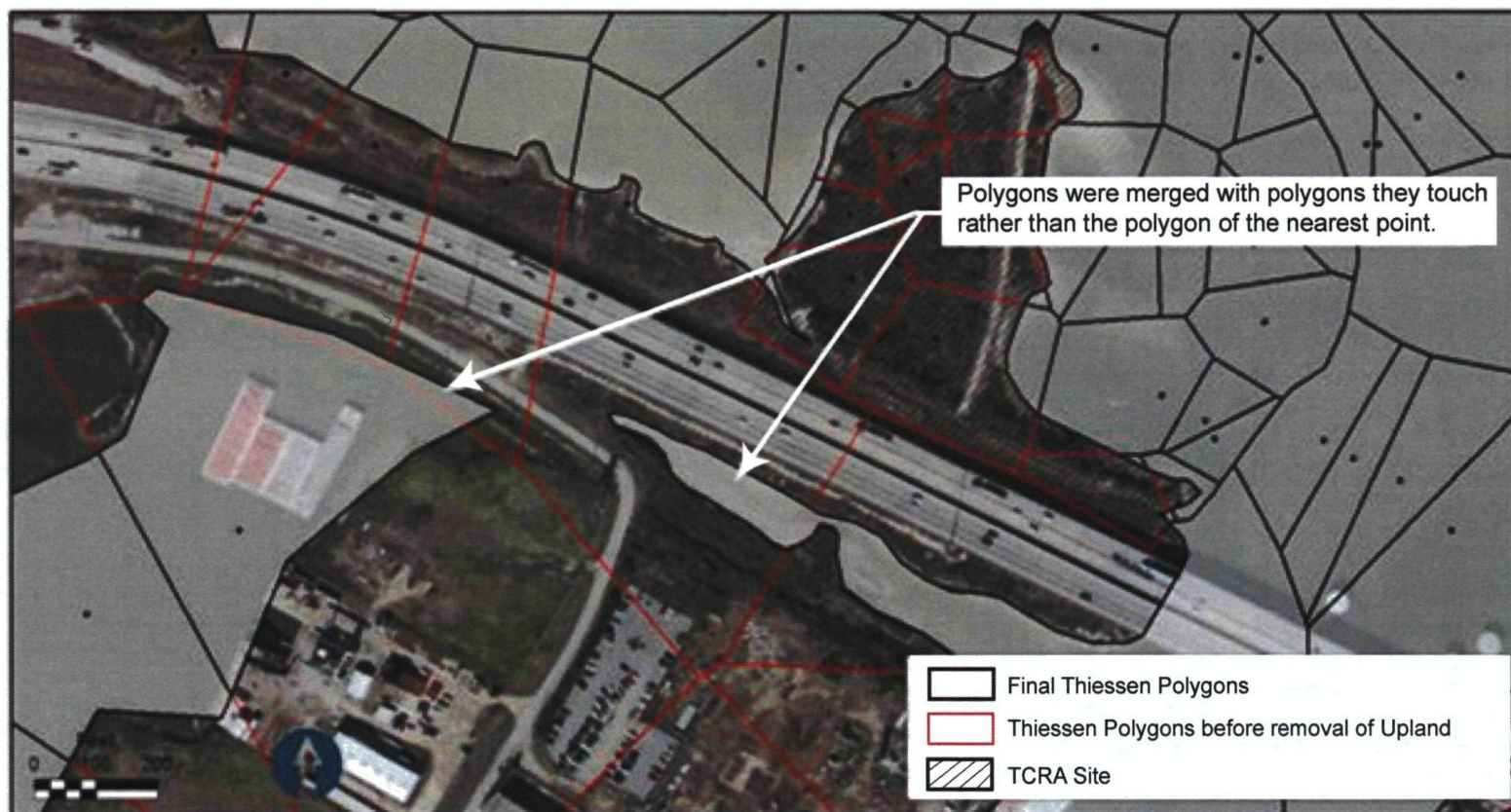


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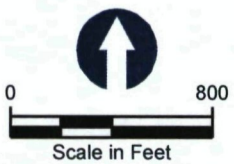
- Surface Soil Sampling Locations
- ✂ TCRA Fence Line
- ✂ Coastal Water Authority Fence Line
- ▭ Original 1966 Perimeter of the Impoundments North of I-10
- ▭ Approximate TCRA Footprint
- ▭ USEPA's Preliminary Site Perimeter

**Figure F-4**  
Exposure Unit for Soils, Area North of I-10 and Aquatic Environment, Post-TCRA  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site





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- USEPA's Preliminary Site Perimeter
- Original 1966 Perimeter of the Impoundments North of I-10
- Clams and Small Fish
- Small Fish
- Clams
- Large Fish and Blue Crab Fish Collection Areas

\* Designation of the sand separation area is intended to be a general reference to areas in which such activities are believed to have taken place based on visual observations of aerial photography from 1998 through 2002.

FEATURE SOURCES:  
Aerial Imagery: 0.5-meter January 2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIS

**Figure F-6**  
Tissue Sampling Locations within  
USEPA's Preliminary Site Perimeter  
Draft Baseline Human Health Risk Assessment  
San Jacinto River Waste Pits Superfund Site

**APPENDIX G**  
**EXPOSURE ASSUMPTIONS FOR**  
**PROBABILISTIC ASSESSMENT**

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# APPENDIX G

## EXPOSURE ASSUMPTIONS FOR PROBABILISTIC ASSESSMENT SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

---

### **Prepared for**

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### **List of Attachments**

Attachment 1.	Crystal Ball Assumptions Report
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## LIST OF ACRONYMS AND ABBREVIATIONS

ABS <sub>d</sub>	dermal absorption factor
BHHRA	baseline human health risk assessment
COPC <sub>H</sub>	chemicals of potential concern for human health
DLC	dioxin-like compound
EPC	exposure point concentration
HI	hazard index
I-10	Interstate Highway 10
NHANES	National Health and Nutrition Examination Survey
PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzo- <i>p</i> -dioxin/polychlorinated dibenzofuran
PRA	probabilistic risk assessment
RBA	relative bioavailability adjustment
RBA <sub>soil-sediment</sub>	relative bioavailability adjustment for soil and sediment
RBA <sub>tissue</sub>	relative bioavailability adjustment for fish and shellfish tissue
Site	San Jacinto River Waste Pits site in Harris County, Texas
TCDD	tetrachlorodibenzo- <i>p</i> -dioxin
USEPA	U.S. Environmental Protection Agency

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## 1 INTRODUCTION

For the baseline human health risk assessment (BHHRA) for the San Jacinto River Waste Pits site in Harris County, Texas (the Site)<sup>1</sup>, a probabilistic risk assessment (PRA) was completed for those hypothetical exposure scenarios that met one or more of the defined thresholds established for completing this additional analysis. PRA uses probability distributions to characterize variability or uncertainty in exposure and risk estimates (USEPA 2001), and ultimately offers more detailed insight into both the magnitude and probability of exposure and risk.

Probabilistic analyses were completed using Oracle® Crystal Ball software (Gentry et al. 2005). Crystal Ball employs Monte Carlo analysis, a commonly used probabilistic numerical technique in the field of risk assessment. Monte Carlo analysis uses computer simulation to combine multiple probability distributions by repeatedly sampling values from multiple input distributions to yield a distribution of output values (USEPA 2001).

The purpose of this appendix is to present the probability distributions that were used in the PRA for the area north of Interstate Highway 10 (I-10) and the aquatic environment. An overview of the hypothetical exposure scenarios, exposure pathways, and chemicals of potential concern for human health (COPC<sub>HS</sub>) evaluated in the PRA, as well as the two receptor populations modeled for the PRA is provided as a basis for describing the specific parameter distributions that were required. Following these discussions the probability distribution and the supporting rationale for each exposure parameter are presented.

## 2 OVERVIEW OF SCENARIOS AND COPC<sub>HS</sub> EVALUATED

A PRA was completed for any hypothetical exposure scenario for which the results of the deterministic evaluation met one or more of the following criteria:

- The cumulative exposure from all pathways resulted in estimated excess cancer risk  $>1 \times 10^{-4}$

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<sup>1</sup> References to “the Site” in this document are intended as reference to the formally designated Superfund site and not to a geographical area.

- 
- The cumulative exposure from all pathways resulted in a total endpoint-specific estimated noncancer hazard index (HI) >1
  - The cumulative exposure from all pathways resulted in an estimated dioxin cancer HI >1.

While none of the hypothetical exposure scenarios included in the baseline deterministic evaluation resulted in an estimated cancer risk greater than  $1 \times 10^{-4}$ , certain scenarios resulted in endpoint-specific noncancer HIs >1 and/or dioxin cancer HIs >1. These scenarios are outlined in Table G-1 and include scenarios for hypothetical young child recreational fishers, young child subsistence fishers, and young child recreational visitors. Assumed exposure pathways in these scenarios included the ingestion of fish and shellfish, incidental ingestion of soil and sediment, and dermal contact with soil and sediment. Only COPCHs that were defined as risk driving chemicals in the BHHRA were included in the PRA.<sup>2</sup> These were TEQ<sub>DF</sub> in sediment, fish and shellfish tissues, and soils; polychlorinated biphenyls (PCBs) in catfish, crabs and clams; and methylmercury in catfish fillet.

### 3 POPULATIONS MODELED

Two potential receptor populations were modeled for the PRA: a hypothetical young child fisher and a hypothetical young child recreational visitor. Although the deterministic risk evaluation treated the hypothetical recreational and subsistence fisher populations separately, a single fisher population consisting of all individuals who catch and ingest fish from within the U.S. Environmental Protection Area (USEPA) Preliminary Site Perimeter<sup>3</sup> was modeled for the PRA. A brief description of the two potential receptor populations evaluated and the rationale for the analysis of a single fisher population are provided below.

#### 3.1 Hypothetical Young Child Fisher

The hypothetical young child fisher was assumed to be 1 to 6 years old and to have direct contact with sediment and ingests fish or shellfish from within USEPA's Preliminary Site Perimeter. The model developed for each exposure scenario for the hypothetical young

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<sup>2</sup> Risk drivers were defined as COPCHs that contributed  $\geq 5$  percent of overall risk or hazard across all exposure pathways that made up the selected scenario, and contributed greater than five percent to the pathway specific risk or hazard associated with the medium of interest.

<sup>3</sup> For the purposes of this document, the term "USEPA's Preliminary Site Perimeter" refers to the area shown within the "preliminary perimeter" in Appendix B of the UAO.

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child fisher assumed a range of exposures that was inclusive of the behaviors of both hypothetical recreational and subsistence fishing populations. The models were set up in this manner so that the impact of true variability in behaviors and patterns of exposure across the entire hypothetical fisher population could be captured and explored. While the labels “recreational fisher” and “subsistence fisher” used in the deterministic analysis imply that there are two completely separate populations that have different and unique characteristics, it is appropriate to assume that there would be substantial overlap in the behaviors of average and high consuming individuals. For example, some hypothetical fishers who consume large amounts of finfish on an annual basis can be assumed to obtain only a small portion of their total catch from within USEPA’s Preliminary Site Perimeter while other high consumers can be assumed to obtain most of their fish from that area. At the same time, there may be individuals who are assumed to consume fish at high rates but to only fish within USEPA’s Preliminary Site Perimeter during a single season while others may be assumed to fish there for many years. The same variations in behavior can be assumed to occur within the fisher population that consumes fish at more typical rates. Therefore, while some of the individuals evaluated in the PRA may be assumed to display behaviors that are similar to the assumptions used for the deterministic analysis of hypothetical recreational fishers and some may display behaviors that resemble the behaviors assumed for the deterministic analysis of the hypothetical subsistence fisher, others can be assumed to have characteristics that more closely resemble a combination of the assumptions used for these two populations. The PRA analysis for the hypothetical young child fisher was developed to capture the highly variable behaviors within the entire population of fishers who may catch fish within USEPA’s Preliminary Site Perimeter. The manner in which the distributions developed for the PRA captured both typical and high-end fishing and consumption activities is provided within the context of their definitions below.

### **3.2 Hypothetical Young Child Recreational Visitor**

The hypothetical young child recreational visitor was assumed to be 1 to 6 years old and to visit the area within USEPA’s Preliminary Site Perimeter for recreational purposes. It was assumed that this individual would have direct contact with soils and sediment while visiting this area.

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## 4 EXPOSURE PARAMETERS

For the PRA, probability distributions of exposure parameters replaced the point estimates used in the deterministic analysis to yield an output probability distribution rather than a single output value for the exposure estimate. A probability distribution is a mathematical function that describes the range of possible values for a parameter and the associated probabilities for those values. Each distribution characterizes variability and/or uncertainty within the modeled population. Parameter variability is an inherent reflection of the natural variation within a population. Uncertainty represents limited or lack of perfect knowledge about specific variables, models, or other factors. The focus of this PRA was to model variability in exposure (and resulting risk), however all of the distributions used for the PRA inherently represent varying amounts of uncertainty and variation.

Probability distributions were developed from empirical data available in the literature and from using best professional judgment. In line with recommendations for probabilistic modeling (USEPA 2001; Finley et al. 1994; ODEQ 1998), the shape of the distribution that was defined was dependent on the availability and certainty of data. For example, a triangular distribution is a “rough” probability model that generally describes the variability of a parameter based on limited information (USEPA 2001). This distribution type can be viewed as a conservative characterization of truncated normal or lognormal distributions, because it will result in more frequent selection of values in the extremes of the parameter’s distribution (Finley et al 1994). In comparison, when the available information allows, a more precise distribution (e.g., normal or lognormal) may be developed.

Attachment 1 provides an overview of the distributions used for the PRA in the form of a report generated by Crystal Ball.

### 4.1 Exposure Point Concentrations

Exposure point concentrations (EPCs) were established for the COPCHs that were identified as risk drivers in the scenarios selected for analysis. Specifically, COPCHs included a toxicity equivalent for dioxins and furans calculated using mammalian toxicity equivalency factors (TEQ<sub>DF</sub>) in sediments, soils, and edible tissues; PCBs in all edible tissues; and methylmercury in catfish fillet.

---

Probability distributions were developed for the EPCs for each COPC<sub>H</sub> based on the best-fitting distributions of the data, which was determined when establishing the CTE and RME EPCs used in the deterministic evaluation. The EPC distributions were bound at the high and low ends to avoid the inclusion of extreme high end and negative values. For datasets with sample sizes of less than 15, the upper bound for the EPC was established as the mean value plus three standard deviations. For datasets with sample sizes equal to or greater than 15, the maximum concentration in the distribution was established as the maximum detected concentration. This sample size-dependent approach was used because larger datasets allow for more complete characterization of the conditions within USEPA's Preliminary Site Perimeter. The lower bound for all distributions was a minimum concentration of zero.

## **4.2 Common Parameters**

### **4.2.1 Exposure Duration and Averaging Time**

For the hypothetical young child receptor's exposure duration, a triangular distribution with a minimum value of 1 year, a most likely value of 3.5 years, and a maximum value of 6 years was used. This distribution was selected based on best professional judgment with the maximum value set to the RME exposure duration used for the young child in the deterministic evaluation.

Only noncancer and cancer HIs were evaluated in the PRA because none of the non-threshold cancer risks exceeded the defined benchmark for additional analysis. As a result, in all cases, the averaging time was set to equal the randomly selected exposure duration for each iteration of the probabilistic model.

### **4.2.2 Body Weight**

A lognormal distribution with a mean of 17.27 kg and standard deviation of 4.97 kg was used to represent the body weight distribution for the young child receptors. This relationship was derived by Portier et al. (2007) for children ages 1 through 6 years, based on National Health and Nutrition Examination Survey (NHANES) IV data. This distribution was bound at the lower and upper ends, based on best professional judgment and using lower and upper percentiles of body weight for the defined population as follows: the minimum was set to one

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half the 5th percentile weight for girls between ages 1 and 2 years, and the maximum was calculated as twice the 95th percentile weight for boys between the ages of 3 and 6 years, based on data presented from NHANES IV (USEPA 2011).

### **4.3 Parameters for Tissue Ingestion**

#### **4.3.1 Ingestion Rate for Fish**

The input distribution for assumed fish consumption rates for young children was drawn from the raw data collected during the Lavaca Bay (Alcoa 1998) survey. To calculate daily ingestion rates, the masses (in grams) of finfish consumed by small children during a 1 month period were divided into 30 day increments to derive an average daily consumption rate in g/day. The calculated rates ranged from a minimum of 0 g/day to a maximum of 288 g/day.

The empirical finfish consumption rates drawn from the Lavaca Bay study were used directly as the input distribution for the finfish ingestion rate term. A summary of the resulting distribution is provided in Table G-2.

#### **4.3.2 Ingestion Rate for Shellfish**

A similar approach was used to develop a distribution for assumed shellfish ingestion rates for the hypothetical young child fisher. The Lavaca Bay survey results contained 326 records for children who consumed finfish during the study period; however, only 29 of these individuals consumed shellfish during the month-long period in which the study was conducted. Although the remaining records represented fish consumers, these individuals did not consume shellfish during the study period. Consequently, the population of fish consumers was quite large, but the subset of individuals who consumed shellfish was quite small, which is not surprising given that shellfish are a subcategory of total fish consumption.

The report on Lavaca Bay recognized this issue and included zero values for the large number of the fish consumers who did not consume shellfish when they derived the reported statistics for consumption rates for shellfish. The empirical data on shellfish ingestion for individuals (including zero values for non-shellfish consumers) were used as the input distribution for the shellfish ingestion rate term. A summary of the resulting distribution is provided in Table G-2.

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#### **4.3.3 Additional Discussion for Tissue Ingestion Rates**

Finfish and shellfish ingestion rates were estimated using the findings of the Lavaca Bay study. Subsistence fishers, if present, are assumed to be a subpopulation of individuals who consume more fish than a typical angler because they rely on self-caught fish as their primary source of protein. As such, they represent the upper end of the fish consumption rate distribution, but are already included in the range of fish consumption rates that bound that input distribution. For example, the maximum finfish consumption rate estimated for young children was 288 g/day. In the context of a single site, this equates to roughly 10 ounces of fish consumed from a single location by a 1 to 6 year old child, every day of the year, throughout the 6-year exposure period. It is unlikely that any child, subsistence or non-subsistence, who consumes fish would consume more fish than this on a daily basis.

The Centers for Disease Control recommend that a child aged 1 through 6 years should consume, on average, 16 g of protein daily for good health (13 g/day for ages 1 to 3 years and 19 g/day for ages 4 to 6 years<sup>4</sup>). Although the protein content of different fish species varies, typically fish tissue contains between 15 and 20 percent protein.<sup>5</sup> Therefore, 288 g/day of fish tissue would provide between 43 and 58 g/day of protein, which is roughly three times the total daily protein requirement of any individual within this age group.

For the reasons discussed above, children evaluated under the hypothetical subsistence fisher scenario in the deterministic BHHRA are represented in the assumed consumption rate distribution that has been developed for the PRA.

#### **4.3.4 Fraction of Tissue from within USEPA's Preliminary Site Perimeter**

The fraction of total fish or shellfish consumed by hypothetical fishers that is harvested from any given area is likely to vary considerably. Most anglers do not fish a single location throughout their fishing careers. Therefore, for most anglers who may fish within USEPA's Preliminary Site Perimeter, only a fraction of their total consumption would consist of recreationally caught fish from this area. The Lavaca Bay study indicated that less than 1 percent of anglers surveyed fished the identified 1,500 acre subarea of that site (Alcoa

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<sup>4</sup> See <http://www.cdc.gov/nutrition/everyone/basics/protein.html>

<sup>5</sup> See <http://www.fao.org/wairdocs/tan/x5916e/x5916e01.htm>.

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1998). At the same time, it is conceivable that someone could live near a given fishing area and it could be assumed that for the entire exposure period, that person would obtain a relatively large percentage of their fish from that area. In order to represent the potential variability in the fraction of fish or shellfish that may be harvested and consumed from within USEPA's Preliminary Site Perimeter, a triangular distribution was used with a most likely value of 25 percent, a minimum value of 1 percent, and a maximum value of 100 percent. This distribution reflects the fact that the fraction is likely to vary substantially among individuals and over time.

#### **4.4 Parameters for Direct Contact**

##### **4.4.1 Fraction of Total Direct Contact to Sediment and Soil**

The fractions of total intake that were assumed to be soil versus sediment were maintained as the same point estimates that were adopted for the deterministic evaluation. It was assumed that 100 percent of exposure for the hypothetical child fisher would be to sediment and that hypothetical child recreational visitors would be equally exposed to sediment (50 percent) and soil (50 percent).

##### **4.4.2 Sediment and Soil Ingestion Rates**

Although the goal of characterizing variability in ingestion rates is to ascertain the variability in average rates over long time periods (i.e., years), relevant soil ingestion studies have been performed over much shorter time periods (i.e., days). Estimates of ingestion rates derived from short-term studies overestimate the upper percentile values of soil ingestion over longer averaging times. In other words, the highest intake rates observed in a short-term study will be much higher than the highest intake rates when the behavior of the study group is averaged over a longer time period. Long-term daily average intakes are, therefore, desired to more accurately represent child and adult soil ingestion rates when evaluating chronic exposures.

For assumed sediment and soil ingestion rates, a lognormal distribution with an arithmetic mean of 31 mg/day and a standard deviation of 31 mg/day was used for both young child receptors. This distribution was based on long-term estimates of soil ingestion rates for children obtained from a tracer-element study of 64 children from Anaconda, Montana.

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Stanek and Calabrese (2001) presented a re-analysis of previously collected data that offered several methodological improvements over prior analyses, including data for seven tracer elements and incorporating bootstrapping to predict long term (annual) ingestion rates<sup>6</sup>. This was consistent with a distribution derived by Ozkaynak et al. (2011) based on U.S. Environmental Protection Agency's (USEPA's) SHED Multimedia model, a probabilistic exposure model that combined diary information with other relevant modeling parameters. Although Stanek and Calabrese (2001) reported a long term maximum child soil ingestion rate of 137 mg/kg, the maximum value of 1,000 mg/kg for pica behavior, recommended in USEPA's *Exposure Factors Handbook* (USEPA 2011), was selected as the maximum rate for the input distribution. A minimum assumed ingestion rate of 0 mg/day was used to avoid the possibility of negative ingestion rates.

#### **4.4.3 Exposed Surface Area**

The exposed surface area was calculated as the product of two terms: total age-specific surface area of the individual and the percent of surface area exposed:

$$SA_{\text{exposed}} = SA_{\text{total}} \times \% \text{ surface area exposed}$$

For each iteration of the model, the total surface area was calculated as a function of the selected body weight for that iteration, using the following equation established by Burnmaster (1998):

Where:

$SA_{\text{total}}$  = the total surface area in square centimeters  
BW = body weight in kg

Several formulae have been developed to estimate total body surface area as a function of body height and body weight. Murray and Burmaster (1992) found that assuming a correlation between height and body weight influenced the final distribution by less than

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<sup>6</sup> Estimates of ingestion rates derived from short-term studies have been shown to overestimate upper percentile values of soil ingestion over longer averaging times (Stanek and Calabrese, USEPA 2002).

---

1 percent. Given these findings, the relationship between surface area and body weight developed by Burmaster (1998) was selected as a reasonable method for calculating total surface area as a function of body weight. This method allowed for the established correlation between body weight and surface area (USEPA 2011) to be accounted for, so that for any given iteration, an especially high body weight from the distribution of values was not paired with an especially low surface area value.

The percent surface area exposed was modeled as a range, representing various combinations of the face, arms, hands, legs, and feet exposed. The factor was assigned a triangular distribution with the most likely value of 31 percent was based on the percentage of total surface area for face, forearms, hands, lower legs, and feet. The minimum value of 14 percent was based on the assumption that only the face, forearms, and hands were exposed, while the maximum value of 54 percent was based on the assumption that the face, entire arm, hands, entire leg, and feet were exposed. All values were derived as age-weighted values for a young child age 1 through 6 years, using data presented in USEPA's Exposure Factors Handbook (USEPA 2011).

#### **4.4.4 Adherence Factor for Sediment**

The adherence factor distribution for sediment was defined as a uniform distribution with a minimum value of 0.09 mg/cm<sup>2</sup> and maximum value of 3.6 mg/cm<sup>2</sup>. The maximum value was based on body part-specific adherence factors from Shoaf et al. (2005) in which surface-areas were weighted to reflect the exposed body parts, as described above. Shoaf et al. (2005) evaluated children playing in tidal flats that were primarily composed of sandy sediments and established adherence factors ranging from 0.042 mg/cm<sup>2</sup> for the face to 21 mg/cm<sup>2</sup> for the feet.

Sediments collected from within USEPA's Preliminary Site Perimeter include a range of particle sizes with the bulk being finer grained sediments including silt, very fine sand, and fine sand. Overall, these sediments appear to be finer than those studied by Shoaf et al. (2005). In the absence of specific data on adherence to sediments with characteristics similar to those from within USEPA's Preliminary Site Perimeter (i.e., fine grained), a minimum value of 0.09 mg/cm<sup>2</sup> was adopted; this value was derived from a study that measured soil

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adherence in children and their body-specific adherence factors (USEPA 2011). The value of 0.09 mg/cm<sup>2</sup> is similar to what has been measured in other adherence studies with soil (USEPA 2011). In this instance, the range of sediment adherence factor values represents both variability and uncertainty in adherence that could occur.

No correlation between the exposed surface area and sediment adherence factors was assumed. Thus, for each iteration of the model, a value for exposed surface area and a sediment adherence factor was randomly and independently selected. There is evidence that soil and sediment adheres to some body parts, such as the feet and hands, to a greater degree than to others (USEPA 2011). The distributions developed for exposed surface area and sediment adherence factors, however, were not correlated for the PRA model. This was because the manner in which the exposed surface area was calculated did not designate specific body-parts that were exposed rather the range of exposed surface areas was based on several combinations of body parts that might potentially be exposed. The application of the adherence factor weighted to the most likely body parts exposed was determined to be an appropriate approach that would not underestimate adherence. This is because the weighted-averages used to derive the upper and lower end of the distribution incorporate the adherence factors for the specific parts of the body for which adherence is known to be greatest (i.e., the hands and feet).

#### **4.4.5 Adherence Factor for Soil**

A distribution for the soil adherence factor was not developed. For the PRA, this parameter was treated as a point estimate of 0.09 mg/cm<sup>2</sup> and is the same value that was selected for the deterministic evaluation. The choice to not develop a soil adherence factor distribution was based on the fact that the BHHRA for the area north of I-10 and the aquatic environment found that direct contact with soils accounted for less than 1 percent of the hypothetical exposure and resulting estimated baseline hazard. Therefore, the impact of any variable term assumed for the soil adherence factor would be minimal and would not substantially affect the probabilistic risk results.

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#### **4.4.6 Exposure Frequency for Direct Contact Pathways**

Two distributions for exposure frequency to soils and sediments were established: one for the hypothetical fisher and one for the hypothetical recreational visitor. The selected values were centered around the factors adopted for the deterministic risk calculation. In the deterministic evaluation, point estimates of 13 days/year (CTE), and 39 days/year (RME) were adopted for the hypothetical recreational fisher and a value of 104 days/year was used for the hypothetical subsistence fisher (RME). The hypothetical recreational fisher CTE value of 13 days/year was based on the findings of a survey of Texas anglers completed by the U.S. Fish and Wildlife Service (USFWS 2008), that reported the mean number of days spent fishing marine waters by Texas residents was 13 days/year (USFWS 2008). A survey of Maine's freshwater anglers (Ebert et al. 1993), found that the 95th percentile frequency of fishing trips per year was nearly 3 times that of the average number of fishing trips per year, and this factor was used in estimating the RME value for hypothetical recreational fishing scenarios of 39 days/year. The RME value used for the hypothetical subsistence fisher scenario in the deterministic evaluation was 104 days/year based on best professional judgment and assuming that over the assumed entire exposure duration an individual frequents the area within USEPA's Preliminary Site Perimeter, 2 days/week on average. It is plausible, however, that a hypothetical young child fisher might frequent the area within USEPA's Preliminary Site Perimeter either less often or more frequently. To model this variability for the PRA, for the hypothetical young fisher a triangular distribution with a most likely value of 13 days/year, minimum value of 1 day/year, and maximum value of 156 days/year (assuming 3 days/week over the course of the duration period) was adopted.

For the hypothetical recreational visitor, a triangular distribution with a most likely value of 52 days/year, minimum value of 1 day/year, and maximum value of 156 days/year was used for the PRA. This distribution corresponds with the assumption that an individual would most likely frequent the area within USEPA's Preliminary Site Perimeter an average of 1 day/week throughout the year, with a minimum of 1 day/week and a maximum of 3 days/week throughout the year.

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#### **4.4.7 Fractional Intake of Soils and Sediments from within USEPA's Preliminary Site Perimeter**

The distribution for fractional intake of soils and sediments from within USEPA's Preliminary Site Perimeter was also generated based on the values assumed for the deterministic evaluation. For the deterministic evaluation, a conservative fractional intake of 1.0 was adopted for the RME fisher and recreational visitor and a fractional intake of 0.5 was adopted for the CTE for both receptor groups. Because it is envisioned that a hypothetical recreational visitor might spend one hour or less per day in the area within USEPA's Preliminary Site Perimeter, but could also potentially spend many hours there, a triangular distribution for fractional intake with a most likely value of 0.5, a minimum of 0.1, and maximum of 1 was adopted for the PRA.

It is possible that a hypothetical fisher might spend longer periods of time in the area within USEPA's Preliminary Site Perimeter on any given day than would a hypothetical recreational visitor. Therefore, a higher fractional intake was adopted for the PRA analysis of the fisher. For this receptor, a triangular distribution with a most likely and maximum value of 1.0 and a minimum value of 0.5 was assumed.

#### **4.5 Chemical Specific Factors**

Chemical-specific oral bioavailability, dermal absorption and cooking loss distributions were developed for dioxins and furans (all media), PCBs (all media), and methylmercury (catfish fillet only) for the PRA. These are discussed below.

##### **4.5.1 Relative Oral Bioavailability**

Relative bioavailability adjustment (RBA) factors for oral pathways are used to account for the differences in chemical bioavailability in specific exposure media (i.e., soil, sediment, tissue) compared to the dosing vehicle used in the critical toxicity study that provides the basis for the COPCH-specific toxicity criteria selected for use in the BHHRA.

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The RBA can be expressed as:

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(eq 4-1)

Little information is available with which to quantify the relative bioavailability of COPCHs in fish and shellfish tissue ( $RBA_{\text{tissue}}$ ). This factor was assumed as 1.0 for all COPCHs included in the PRA.

The oral RBA for soil and sediment ( $RBA_{\text{soil-sediment}}$ ) for dioxins and furans was defined as a lognormal distribution with an arithmetic mean value of 0.6 and standard deviation of 0.28. Minimum and maximum values were set to 0 and 1, respectively. This distribution was derived using data on the bioavailability of tetrachlorodibenzo-*p*-dioxin (TCDD) in soils obtained from a range of studies selected and presented by USEPA (2010) in their *Final Report on Bioavailability of Dioxins and Dioxin Like Compounds in Soil*. A summary of the bioavailability reported by these studies is provided in Table G-3.

USEPA (2010) summarized ten studies that reported a total of 29 RBA test results for TCDD and polychlorinated dibenzo-*p*-dioxin/polychlorinated dibenzofuran (PCDD/F)<sup>7</sup> in soil and sediment over a range of concentrations up to 2,300 ng/g. The selected studies provided RBA estimates in test materials consisting of soil and sediment that contained with dioxins/furans in situ. Studies of spiked soil materials were not included in the analysis because aging of dioxins and furans in soil may decrease their bioavailability. To derive the  $RBA_{\text{sediment-soil}}$  probability distribution the average bioavailability reported for each study was calculated. The average value from each study was then divided by the absorption fraction of 50 percent that was assumed in back-calculating the toxicity criteria for dioxins used in this BHHRA (i.e., indicated in equation 4-1 as “absorbed fraction from dosing medium used in toxicity study” (JECFA 2002). The resulting values across all of the studies exhibited a lognormal distribution (Appendix B of USEPA 2001) and were used to define the  $RBA_{\text{soil-sediment}}$  probability distribution for the PRA.

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<sup>7</sup> Study results for TCDD and PCDD/F were selected for characterizing bioavailability for TEQ<sub>DF</sub> because due to their large TEF, these compounds account for the vast majority of the TEQ<sub>DF</sub> metric being modeled in the exposure assessment.

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Given the differences in behavior between various dioxin-like compounds (DLCs) in the environment, there is some uncertainty associated with the application of a value based on TCDD to all DLCs.

#### **4.5.2 Dermal Absorption Factor for Soil and Sediment**

The dermal absorption factor (ABS<sub>d</sub>) for dioxins and furans was defined as a uniform distribution with a minimum value of 0.01 and a maximum value of 0.03.

The dermal absorption factor represents the proportion of a chemical that is absorbed across the skin from the soil and/or sediment matrix once it has been contacted. Dermal absorption is dependent on the properties of the chemical itself, as well as on external factors including the physical properties of the soil or sediment matrix (e.g., particle size and organic carbon content) and the conditions of the skin (e.g., skin condition, moisture content). Data with which to characterize dermal absorption of chemicals from sediment is not readily available and dermal absorption of chemicals from soil and sediment matrices will differ to some degree. In the absence of sediment-specific information, USEPA (2004) supports the application of factors derived for soil to sediment.

The available literature supports that the ABS<sub>d</sub> value for dioxins/furans varies between 1 and 3 percent in soils and sediments with low organic content like those within USEPA's Preliminary Site Perimeter. USEPA (2004A) recommends a value of 0.03 which was adopted in the deterministic risk evaluation. More recently, Roy et al. (2008) conducted dermal absorption experiments using TCDD sorbed on low organic soil or high organic soil at 1 ppm. Following application for 96 hours to rat skin *in vivo* and *in vitro*, and to human skin *in vitro*, the percents absorbed of applied dose in low organic soil were 16.3 percent (rat *in vivo*), 7.7 percent (rat *in vitro*), and 2.4 percent (rat *in vivo*), respectively. One percent of applied dose in high organic soil was absorbed by rat skin *in vitro*. Roy et al. (2008) observed that rat skin was 3 to 4 times more permeable to TCDD than human skin. Accounting for differences between *in vitro* and *in vivo* results and adjusting for monolayer loads, Roy et al. (2008) estimated the 24-hour TCDD absorption for human skin at 1.9 percent for low organic soil and 0.24 percent for high organic soil. Shu et al. (1988) also measured dermal absorption of TCDD from soil matrix applied to rat skin *in vivo*. Concentrations of TCDD at 10, 100 and

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123 ppb were applied for 24 hours, and corresponding dermal absorptions of 1.14, 1.5 and 1.6 percent were reported (Shu et al. 1988).

#### **4.5.3 Chemical Reduction Due to Preparation and Cooking**

It is well recognized that preparation and cooking may reduce chemical concentrations of lipophilic compounds in tissue (USEPA 2000, 2002; Wilson et al. 1998). Distributions for chemical reduction due to preparation and cooking were developed for dioxins and furans and total PCBs<sup>8</sup>. These distributions were based on a meta-analysis of cooking loss studies completed by AECOM (2012). AECOM (2012) identified studies with sufficient data for quantitative analysis of cooking loss for dioxins and PCBs. Specifically, the analysis focused on studies that used a relevant and appropriate experimental method and presented changes in raw and cooked fish tissue COPC levels on a mass basis. The analysis was performed in this manner because a comparison of concentrations in raw and cooked fish alone neglects the change in tissue mass that occurs during cooking, which is often significant. A total of 17 studies that met these criteria were identified. For all tissue types and cooking methods reported, these 17 studies yielded 79 data points for PCBs and 12 data points for dioxins and furans that were used in the quantitative evaluation. The study authors completed an outlier analysis and reported percentiles and statistics for cooking loss for dioxins, furans, and PCBs both with and without extreme and outlier values (Table G-4). The authors concluded that despite the variability, the available data are sufficiently consistent and robust to support inclusion of a quantitative cooking loss factor in the assessment of exposure dose from consumption of fish (AECOM 2012).

The statistics presented by AECOM (2012) with outliers removed were used to develop distributions for the cooking loss terms for the PRA. Cumulative frequency plots generated using dataset percentiles were visually compared to distribution-specific plots available in USEPA (Appendix B of 2001) to select the most appropriate distribution fitting each, given set of percentiles. The selected distribution types and percentile data were then incorporated into Crystal Ball to represent the dioxins and furans and total PCBs cooking loss parameter distributions.

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<sup>8</sup> No cooking loss for methylmercury was assumed. The cooking loss factor for this COPCH was set to 0 percent.

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The loss parameters were applied to catfish fillet tissue only, and not to clams or crabs. No data on chemical reduction due to preparation and cooking specific to shellfish could be located. Clam tissue analyzed from samples collected within USEPA's Preliminary Site Perimeter had a substantially lower percent lipid than most finfish and techniques used for preparing and cooking shellfish differ from those used for finfish. As a result, the application of a loss factor based on cooking loss in finfish was not considered appropriate for shellfish. Therefore, the cooking loss was conservatively estimated at 0 percent for the shellfish ingestion.

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## TABLES

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**Table G-1**  
**Hypothetical Exposure Scenarios for Refined Analysis for the Area North of I-10 and Aquatic Environment**

Scenario	Endpoint Specific Noncancer HI > 1	Cancer Risk > 1E-4	TEQ <sub>DF</sub> Cancer HI > 1
<b>Hypothetical Recreational Fisher</b>			
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3			
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3			
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	X		X
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1			
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3			
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2			
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	X		X
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3			
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3			
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3			
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	X		X
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1			
<b>Hypothetical Subsistence Fisher</b>			
1A - Direct exposure Beach Area A; Ingestion of catfish from FCA 2/3	X		X
2A - Direct exposure Beach Area B/C; Ingestion of catfish from FCA 2/3	X		X
3A - Direct exposure Beach Area E; Ingestion of catfish from FCA 2/3	X		X
4A - Direct exposure Beach Area D; Ingestion of catfish from FCA 1	X		X
1B - Direct exposure Beach Area A; Ingestion of clam from FCA 1/3			
2B - Direct exposure Beach Area B/C; Ingestion of clam from FCA 2	X		
3B - Direct exposure Beach Area E; Ingestion of clam from FCA 2	X		X
4B - Direct exposure Beach Area D; Ingestion of clam from FCA 1/3			
1C - Direct exposure Beach Area A; Ingestion of crab from FCA 2/3			
2C - Direct exposure Beach Area B/C; Ingestion of crab from FCA 2/3			
3C - Direct exposure Beach Area E; Ingestion of crab from FCA 2/3	X		X
4C - Direct exposure Beach Area D; Ingestion of crab from FCA 1			
<b>Hypothetical Recreational Visitor</b>			
Scenario 1 - Direct exposure Beach Area A and Soil North of I-10			
Scenario 2 - Direct exposure Beach Area B/C and Soil North of I-10			
Scenario 3 - Direct exposure Beach Area E and Soil North of I-10	X		X
Scenario 4 - Direct exposure Beach Area D and Soil North of I-10			

**Notes**

Shaded cells indicate endpoint-specific noncancer HI >1, cancer risk >1E-04, or TEQ<sub>DF</sub> cancer HI >1

FCA = fish collection area

HI = hazard index

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

**Table G-2**  
**Summary of Distributions for Consumption of Fish and Shellfish by**  
**Young Children**

<b>Statistic</b>	<b>Finfish g/day</b>	<b>Shellfish g/day</b>
Average	11	0.4
Minimum	0	0.0
10th percentile	3.8	0.0
20th percentile	4.3	0.0
30th percentile	4.3	0.0
40th percentile	4.3	0.0
50th percentile	5.7	0.0
60th percentile	8.5	0.0
70th percentile	11	0.0
80th percentile	13	0.0
90th percentile	21	0.0
95th percentile	29	2.5
Maximum	288	20

**Source**

Analysis of raw data collected during the Lavaca Bay study conducted by Alcoa (1998).

**Table G-3**  
**Summary of RBA Studies of Dioxins in Soil**

Reference <sup>a</sup>	Species	Dioxin and Furan Congener	Reported RBAs (percent)	Average RBA from Study (percent)
Bonaccorsi 1984	Rabbit	TCDD	32	32
Budinsky 2008a	Swine	PCDD/F	23, 27	25
Budinsky 2008b	Rat	PCDD/F	37, 66	51.5
Finley et al 2009	Rat	PCDD/F	16.7, 48.4, 37.7, 46.5, 33.3	36.5
Lucier 1986	Rat	TCDD	22, 45	33.5
McConnell 1984	Guinea pig	TCDD	8,11	9.5
Shu 1988	Rat	TCDD	44, 49, 38, 43, 45, 37	42.7
Umbriet 1986	Guinea pig	TCDD	<1, 24	12.5
Wendling 1989	Guinea pig	TCDD	7, 30, 2, 1.6	10.2
Wittsiepe 2007	Swine	PCDD/F	28.4	28.4

**Source**

USEPA, 2010. Table 1 of Final Report, Bioavailability of Dioxins and Dioxin-Like Compounds in Soil; prepared for U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Environmental Response Team – West, Las Vegas, NV. Prepared by SRC, Inc., Chemical, Biological and Environmental Center, N. Syracuse, NY. Final Report on Bioavailability of Dioxins and Dioxin Like Compounds in Soil.

**Notes**

PCDD = polychlorinated dibenzo-*p*-dioxin

PCDF = polychlorinated dibenzofuran

RBA = relative bioavailability adjustment

TCDD = tetrachlorodibenzo-*p*-dioxin

a - As cited in source document (USEPA 2010).

**Table G-4**  
**Cooking Loss Statistics With and Without Extreme Values and Outliers<sup>a</sup>**

	PCBs <sup>b</sup>		Dioxins and Furans <sup>b</sup>	
	All Data	Without Outliers	All Data	Without Outliers
Median	30	30	50	48
Mean	32	33	53	48
Count	79	77	12	11
Minimum	-17	0	28	28
10th Percentile	13	15	31	29
25th Percentile	21	23	46	46
50th Percentile	30	30	51	48
75th Percentile	42	43	59	55
90th Percentile	53	54	63	62
Maximum	74	74	100	63

**Source**

AECOM, 2012. Summary of cooking loss studies and data evaluation. Technical Memorandum submitted to U.S. Environmental Protection Agency, Region 2 on behalf of the Cooperating Parties' Group (CPG), Remedial Investigation/Feasibility Study, Lower Passaic River Study Area, Diamond Alkali Superfund Site, CERCLA Docket No. 02-2007-2009. July 5. 25 pp.

**Notes**

PCB = polychlorinated biphenyl

a - Statistics from datasets with outliers removed were used for determining probability distributions for the PRA.

b - All values are percentages.

**ATTACHMENT 1**  
**CRYSTAL BALL ASSUMPTIONS REPORT**

Tables G-2 thru G-4.xlsx

**Crystal Ball Report - Assumptions**  
Simulation started on 8/21/2012 at 10:48:30  
Simulation stopped on 8/21/2012 at 10:54:37

Run preferences:

Number of trials run	10,000
Monte Carlo	
Random seed	
Precision control on	
Confidence level	95.00%

Run statistics:

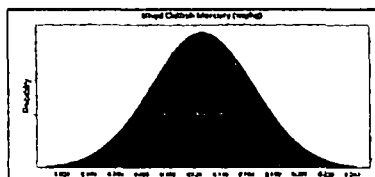
Total running time (sec)	344.93
Trials/second (average)	29
Random numbers per sec	1,566

**Assumption: Bkgd Catfish Mercury (mg/kg)**

Normal distribution with parameters:

Mean	0.126
Std. Dev.	0.039

Selected range is from 0.000 to 0.243

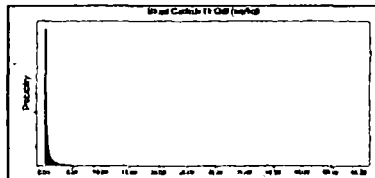


**Assumption: Bkgd Catfish TEQdf (ng/kg)**

Lognormal distribution with parameters:

Location	0.14
Geo. Mean	0.21
Geo. Std. Dev.	6.03

Selected range is from 0.00 to 4.97

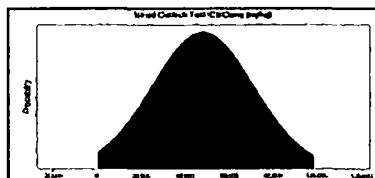


**Assumption: Bkgd Catfish TotPCBCong (ng/kg)**

Normal distribution with parameters:

Mean	48,103
Std. Dev.	23,210

Selected range is from 0 to 98,537



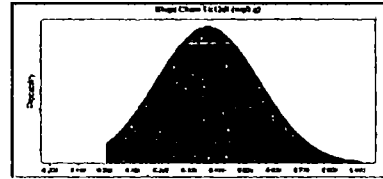
Tables G-2 thru G-4.xlsx

**Assumption: Bkgd Clam TEQdf (ng/kg)**

Normal distribution with parameters:

Mean	0.364
Std. Dev.	0.183

Selected range is from 0.000 to 0.913

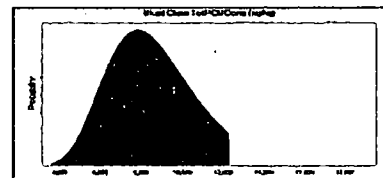


**Assumption: Bkgd Clam TotPCBCong (ng/kg)**

Lognormal distribution with parameters:

Location	0
Geo. Mean	8,376
Geo. Std. Dev.	1

Selected range is from 0 to 12,276

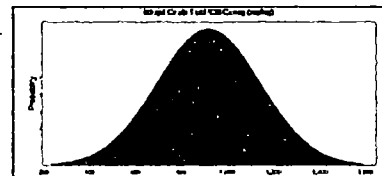


**Assumption: Bkgd Crab TotPCBCong (ng/kg)**

Normal distribution with parameters:

Mean	916
Std. Dev.	223

Selected range is from 0 to 1,584

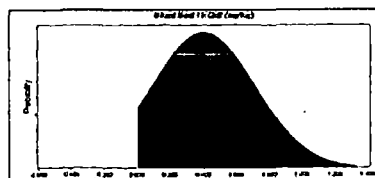


**Assumption: Bkgd Sed TEQdf (ng/kg)**

Normal distribution with parameters:

Mean 0.400  
Std. Dev. 0.310

Selected range is from 0.000 to 1.330

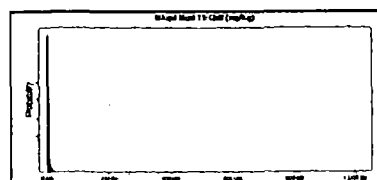


**Assumption: Bkgd Soil TEQdf (ng/kg)**

Lognormal distribution with parameters:

Location 0.40  
Geo. Mean 0.48  
Geo. Std. Dev. 11.94

Selected range is from 0.00 to 23.08

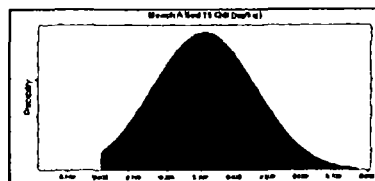


**Assumption: Beach A Sed TEQdf (ng/kg)**

Normal distribution with parameters:

Mean 0.310  
Std. Dev. 0.153

Selected range is from 0.000 to 0.770

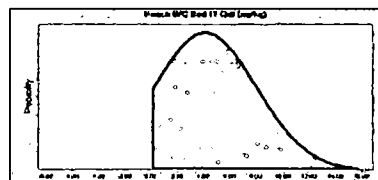


**Assumption: Beach B/C Sed TEQdf (ng/kg)**

Normal distribution with parameters:

Mean 4.09  
Std. Dev. 3.91

Selected range is from 0.00 to 15.81

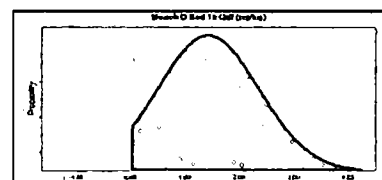


**Assumption: Beach D Sed TEQdf (ng/kg)**

Normal distribution with parameters:

Mean 1.42  
Std. Dev. 0.94

Selected range is from 0.00 to 4.25

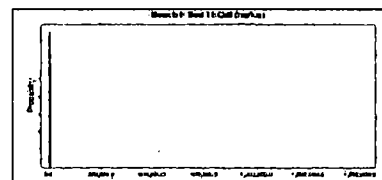


**Assumption: Beach E Sed TEQdf (ng/kg)**

Lognormal distribution with parameters:

Location 0.0  
Geo. Mean 906.5  
Geo. Std. Dev. 11.7

Selected range is from 0.0 to 12,600.0

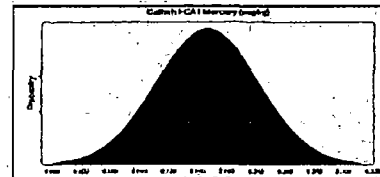


**Assumption: Catfish FCA1 Mercury (mg/kg)**

Normal distribution with parameters:

Mean 0.159  
Std. Dev. 0.053

Selected range is from 0.000 to 0.317

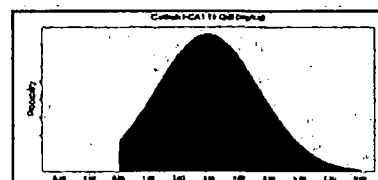


**Assumption: Catfish FCA1 TEQdf (ng/kg)**

Normal distribution with parameters:

Mean 2.94  
Std. Dev. 1.70

Selected range is from 0.00 to 8.02

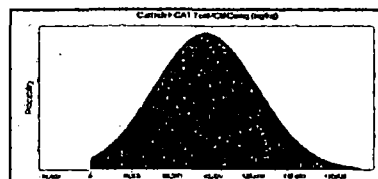


**Assumption: Catfish FCA1 TotPCBCong (ng/kg)**

Normal distribution with parameters:

Mean	84,838
Std. Dev.	37,844

Selected range is from 0 to 198,371

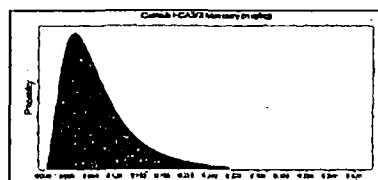


**Assumption: Catfish FCA2/3 Mercury (mg/kg)**

Lognormal distribution with parameters:

Location	0.025
Geo. Mean	0.062
Geo. Std. Dev.	1.836

Selected range is from 0.000 to 0.264

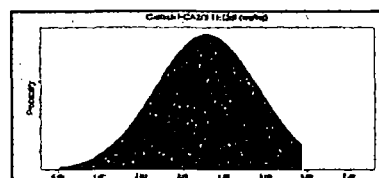


**Assumption: Catfish FCA2/3 TEQdf (ng/kg)**

Normal distribution with parameters:

Mean	3.58
Std. Dev.	1.23

Selected range is from 0.00 to 5.85

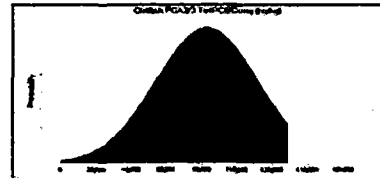


**Assumption: Catfish FCA2/3 TotPCBCong (ng/kg)**

Normal distribution with parameters:

Mean 83,050  
Std. Dev. 28,963

Selected range is from 0 to 129,200

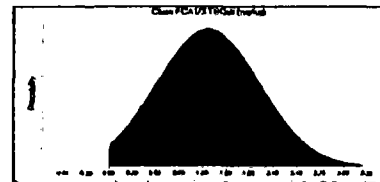


**Assumption: Clam FCA1/3 TEQdf (ng/kg)**

Normal distribution with parameters:

Mean 1.27  
Std. Dev. 0.66

Selected range is from 0.00 to 3.23

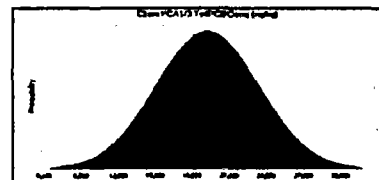


**Assumption: Clam FCA1/3 TotPCBCong (ng/kg)**

Normal distribution with parameters:

Mean 19,250  
Std. Dev. 4,148

Selected range is from 0 to 31,695



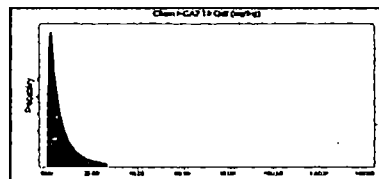
Tables G-2 thru G-4.xlsx

**Assumption: Clam FCA2 TEQdf (ng/kg)**

Lognormal distribution with parameters:

Location	0.00
Geo. Mean	4.42
Geo. Std. Dev.	3.06

Selected range is from 0.00 to 26.97

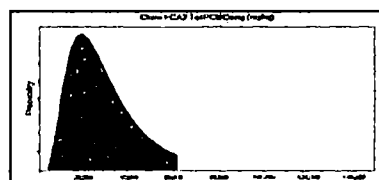


**Assumption: Clam FCA2 TotPCBCong (ng/kg)**

Lognormal distribution with parameters:

Location	0
Geo. Mean	26,032
Geo. Std. Dev.	2

Selected range is from 0 to 61,810

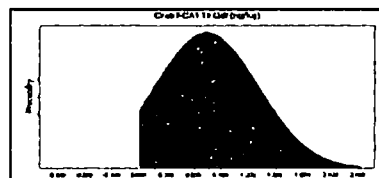


**Assumption: Crab FCA1 TEQdf (ng/kg)**

Normal distribution with parameters:

Mean	0.739
Std. Dev.	0.564

Selected range is from 0.000 to 2.430

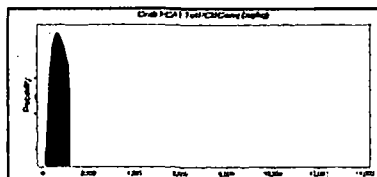


**Assumption: Crab FCA1 TotPCBCong (ng/kg)**

Lognormal distribution with parameters:

Location	0
Geo. Mean	1,158
Geo. Std. Dev.	2

Selected range is from 0 to 1,164

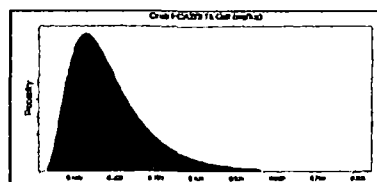


**Assumption: Crab FCA2/3 TEQdf (ng/kg)**

Lognormal distribution with parameters:

Location	0.000
Geo. Mean	0.164
Geo. Std. Dev.	1.677

Selected range is from 0.000 to 0.558

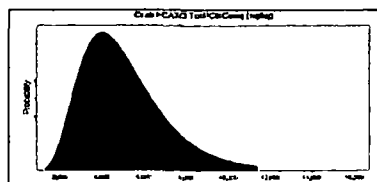


**Assumption: Crab FCA2/3 TotPCBCong (ng/kg)**

Lognormal distribution with parameters:

Location	0
Geo. Mean	4,705
Geo. Std. Dev.	1

Selected range is from 0 to 11,390

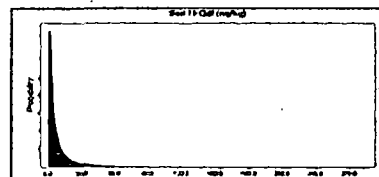


**Assumption: Soil TEQdf (ng/kg)**

Lognormal distribution with parameters:

Location	0.1
Geo. Mean	4.4
Geo. Std. Dev.	3.9

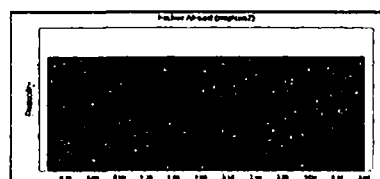
Selected range is from 0.0 to 153.0



**Assumption: Fisher AFsed (mg/cm2)**

Uniform distribution with parameters:

Minimum	0.09
Maximum	3.60

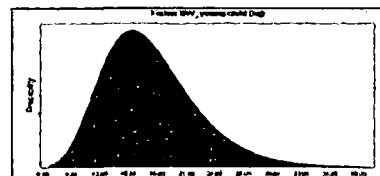


**Assumption: Fisher BW\_young child (kg)**

Lognormal distribution with parameters:

Location	0.00
Mean	17.27
Std. Dev.	4.97

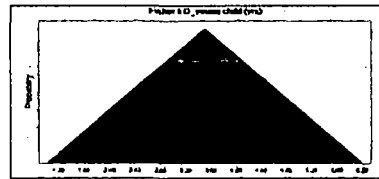
Selected range is from 4.40 to 52.40



**Assumption: Fisher ED\_young child (yrs)**

Triangular distribution with parameters:

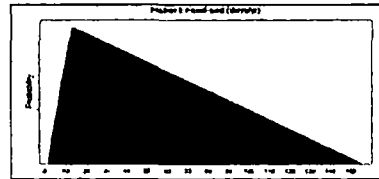
Minimum	1.00
Likeliest	3.50
Maximum	6.00



**Assumption: Fisher EFsoil-sed (days/yr)**

Triangular distribution with parameters:

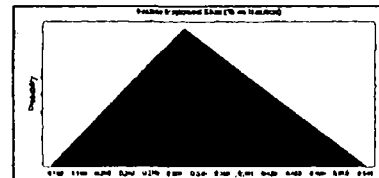
Minimum	1
Likeliest	13
Maximum	156



**Assumption: Fisher Exposed Skin (% as fraction)**

Triangular distribution with parameters:

Minimum	0.143
Likeliest	0.311
Maximum	0.541

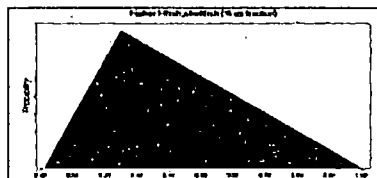


Tables G-2 thru G-4.xlsx

**Assumption: Fisher Flfish,shellfish (% as fraction)**

Triangular distribution with parameters:

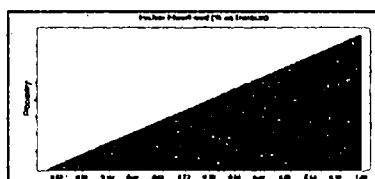
Minimum	0.01
Likeliest	0.25
Maximum	1.00



**Assumption: Fisher Flsoil-sed (% as fraction)**

Triangular distribution with parameters:

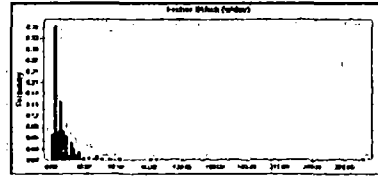
Minimum	0.50
Likeliest	1.00
Maximum	1.00



**Assumption: Fisher IRfish (g/day)**

Custom distribution with parameters:

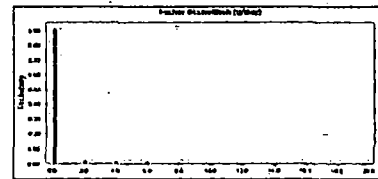
Link to: ='FishIR-Data'!D6:E65



**Assumption: Fisher IRshellfish (g/day)**

Custom distribution with parameters:

Link to: ='FishIR-Data'!J6:K19

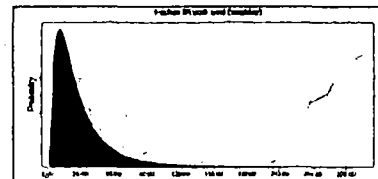


**Assumption: Fisher IRsoil-sed (mg/day)**

Lognormal distribution with parameters:

Location 0.00  
Mean 31.00  
Std. Dev. 31.00

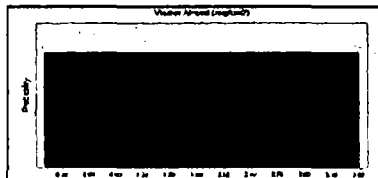
Selected range is from 0.00 to 1,000.00



**Assumption: Visitor AFsed (mg/cm2)**

Uniform distribution with parameters:

Minimum -0.09  
Maximum 3.60

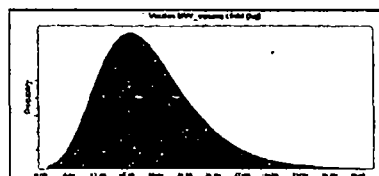


**Assumption: Visitor BW\_young child (kg)**

Lognormal distribution with parameters:

Location	0.00
Mean	17.27
Std. Dev.	4.97

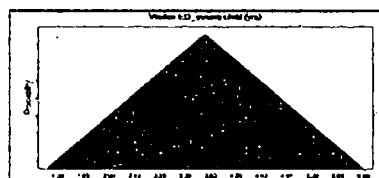
Selected range is from 4.40 to 52.40



**Assumption: Visitor ED\_young child (yrs)**

Triangular distribution with parameters:

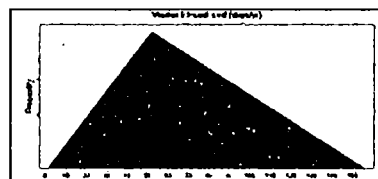
Minimum	1.00
Likeliest	3.50
Maximum	6.00



**Assumption: Visitor EFsoil-sed (days/yr)**

Triangular distribution with parameters:

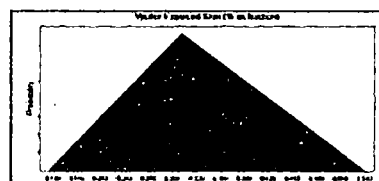
Minimum	1
Likeliest	52
Maximum	156



**Assumption: Visitor Exposed Skin (% as fraction)**

Triangular distribution with parameters:

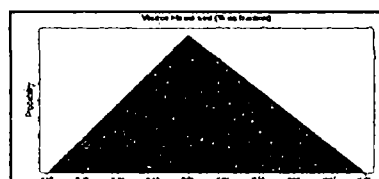
Minimum	0.143
Likeliest	0.311
Maximum	0.541



**Assumption: Visitor FIsoil-sed (% as fraction)**

Triangular distribution with parameters:

Minimum	0.10
Likeliest	0.50
Maximum	1.00



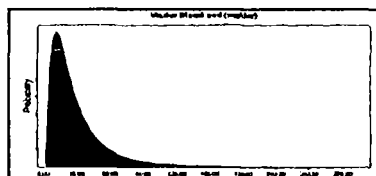
Tables G-2 thru G-4.xlsx

**Assumption: Visitor IRsoil-sed (mg/day)**

Lognormal distribution with parameters:

Location	0.00
Mean	31.00
Std. Dev.	31.00

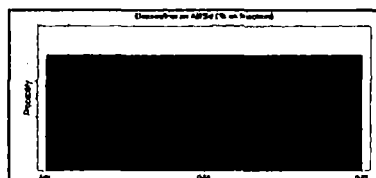
Selected range is from 0.00 to 1,000.00



**Assumption: Dioxin/Furan ABSd (% as fraction)**

Uniform distribution with parameters:

Minimum	0.01
Maximum	0.03

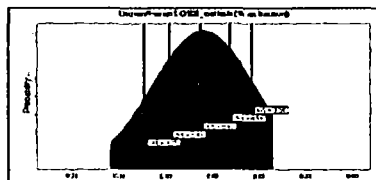


**Assumption: Dioxin/Furan LOSS\_catfish (% as fraction)**

Normal distribution with parameters:

50%	0.48
90%	0.62

Selected range is from 0.28 to 0.63

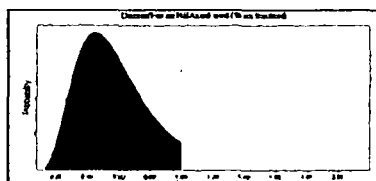


**Assumption: Dioxin/Furan RBAsoil-sed (% as fraction)**

Lognormal distribution with parameters:

Location	0.00
Mean	0.60
Std. Dev.	0.28

Selected range is from 0.00 to 1.00



# Tables G-2 thru G-4.xlsx

Assumption: PCBs (congeners) LOSS\_catfish (% as fraction)

Normal distribution with parameters:

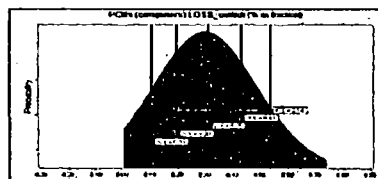
50%

0.30

90%

0.54

Selected range is from 0.00 to 0.74



Hypothetical Recreational Fisher: Exposure Pathway-Specific Noncancer Hazards and Cancer Risks, Area North of I-10 and Aquatic Environment

Table H-1. Site Exposure to Sediment via Incidental Ingestion, Hypothetical Recreational Fisher

Scenario Type: Baseline

Medium: Sediment

Exposure Pathway: Incidental Ingestion

$I_{\text{factor, noncancer, RME}} = 7.03\text{E-}07$

$I_{\text{factor, noncancer, CTE}} = 4.45\text{E-}09$

$I_{\text{factor, cancer, RME}} = 7.46\text{E-}08$

$I_{\text{factor, cancer, CTE}} = 6.85\text{E-}10$

$ADD = I_{\text{sed, noncancer}} \times C_{\text{sed}} \times RBA_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}} \times FI_{\text{sed}} \times EF_{\text{sed}} \times ED \times CF_1 / (BW \times AT_{\text{a}})$

$LADD = I_{\text{sed, cancer}} \times C_{\text{sed}} \times RBA_{\text{sed}} \times IR_{\text{sed}} \times F_{\text{sed}} \times FI_{\text{sed}} \times EF_{\text{sed}} \times ED \times CF_1 / (BW \times AT_{\text{c}})$

$HQ = ADD / RfD$

$Risk = LADD \times CSF$

$I_{\text{sed}} = C_{\text{sed}} \times RBA_{\text{sed}} \times I_{\text{factor}}$

$I_{\text{factor}} = IR_{\text{sed}} \times F_{\text{sed}} \times FI_{\text{sed}} \times EF_{\text{sed}} \times ED \times CF_1 / (BW \times AT)$

COPC <sub>H</sub>	Beach Area A								Beach Area B/C								Beach Area D								Beach Area E								
	Noncancer				Cancer				Noncancer				Cancer				Noncancer				Cancer				Noncancer				Cancer				
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	
Dioxins/Furans																																	
TEQ <sub>DF</sub> (ND = 1/2DL)	1.6E-13	2.3E-04	6.9E-16	9.9E-07	1.7E-14	7.0E-05	1.1E-16	3.0E-07	2.2E-12	3.2E-03	9.1E-15	1.3E-05	2.4E-13	9.7E-04	1.4E-15	4.0E-06	7.5E-13	1.1E-03	3.2E-15	4.5E-06	7.9E-14	3.2E-04	4.9E-16	1.4E-06	4.6E-09	6.5E+00	2.0E-12	2.9E-03	4.9E-10	2.0E+00	3.1E-13	8.8E-04	
TEQ <sub>DF</sub> (ND = DLO)	1.2E-13	1.7E-04	4.4E-16	6.3E-07	1.3E-14	5.2E-05	6.8E-17	1.9E-07	2.2E-12	3.1E-03	8.4E-15	1.2E-05	2.3E-13	9.4E-04	1.3E-15	3.6E-06	7.0E-13	1.0E-03	2.9E-15	4.1E-06	7.5E-14	3.1E-04	4.5E-16	1.3E-06	4.6E-09	6.5E+00	2.0E-12	2.8E-03	4.9E-10	2.0E+00	3.0E-13	8.5E-04	
Metals																																	
Arsenic (inorganic)	1.1E-07	3.5E-04	4.5E-10	1.5E-06	1.1E-08	1.7E-08	6.8E-11	1.0E-10	8.9E-07	3.0E-03	3.5E-09	1.2E-05	9.4E-08	1.4E-07	5.4E-10	8.2E-10	8.5E-07	2.8E-03	4.3E-09	1.4E-05	9.1E-08	1.4E-07	6.6E-10	9.9E-10	6.7E-07	2.2E-03	3.8E-09	1.3E-05	7.1E-08	1.1E-07	5.8E-10	8.7E-10	
Cadmium	7.0E-08	7.0E-05	4.5E-10	4.5E-07	7.5E-09	--	6.8E-11	--	1.5E-07	1.5E-04	3.7E-10	3.7E-07	1.6E-08	--	5.6E-11	--	3.0E-07	3.0E-04	1.5E-09	1.5E-06	3.2E-08	--	2.3E-10	--	1.1E-06	1.1E-03	1.3E-09	1.3E-06	1.2E-07	--	2.0E-10	--	
Chromium (III)	5.8E-07	3.9E-07	2.7E-09	1.8E-09	6.2E-08	--	4.1E-10	--	1.5E-05	1.0E-05	3.6E-08	2.4E-08	1.6E-06	--	5.5E-09	--	7.9E-06	5.3E-06	2.7E-08	1.8E-08	8.4E-07	--	4.1E-09	--	1.1E-05	7.5E-06	3.6E-08	2.4E-08	1.2E-06	--	5.5E-09	--	
Copper	2.5E-06	6.2E-05	3.6E-09	9.0E-08	2.6E-07	--	5.6E-10	--	4.9E-06	1.2E-04	2.5E-08	6.3E-07	5.2E-07	--	3.9E-09	--	5.5E-06	1.4E-04	2.6E-08	6.5E-07	5.9E-07	--	4.0E-09	--	4.0E-05	1.0E-03	7.2E-08	1.8E-06	4.3E-06	--	1.1E-08	--	
Mercury (inorganic)	7.3E-09	2.4E-05	2.6E-11	8.8E-08	7.8E-10	--	4.0E-12	--	1.4E-08	4.7E-05	4.5E-11	1.5E-07	1.5E-09	--	6.8E-12	--	2.8E-08	9.4E-05	8.9E-11	3.0E-07	3.0E-09	--	1.4E-11	--	1.4E-06	4.7E-03	8.9E-10	3.0E-06	1.5E-07	--	1.4E-10	--	
Nickel	2.7E-07	1.3E-05	1.4E-09	7.0E-08	2.8E-08	--	2.2E-10	--	6.2E-06	3.1E-04	2.3E-08	1.2E-06	6.6E-07	--	3.5E-09	--	4.6E-06	2.3E-04	2.4E-08	1.2E-06	4.9E-07	--	3.7E-09	--	6.6E-06	3.3E-04	3.2E-08	1.6E-06	7.0E-07	--	4.9E-09	--	
Zinc	6.1E-06	2.0E-05	1.5E-08	5.0E-08	6.4E-07	--	2.3E-09	--	3.4E-05	1.1E-04	1.1E-07	3.7E-07	3.6E-06	--	1.7E-08	--	3.2E-05	1.1E-04	1.3E-07	4.4E-07	3.4E-06	--	2.0E-08	--	1.6E-04	5.2E-04	2.9E-07	9.6E-07	1.7E-05	--	4.4E-08	--	
Polychlorinated Biphenyls																																	
Sum of Aroclors	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9.8E-07	4.9E-02	2.5E-09	1.2E-04	1.0E-07	2.1E-07	3.8E-10	3.8E-10
Sum of Aroclors (ND = DLO)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sum of 43 PCB Congeners (ND = 1/2DL)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = DLO)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TEQ <sub>2</sub> (ND = 1/2DL)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.6E-12	2.3E-03	6.7E-15	9.5E-06	1.7E-13	6.9E-04	1.0E-15	2.9E-06
TEQ <sub>2</sub> (ND = DLO)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.3E-13	1.2E-03	3.6E-15	5.1E-06	8.8E-14	3.6E-04	5.5E-16	1.6E-06
Semivolatile Organic Compounds																																	
Bis(2-ethylhexyl)phthalate	6.7E-09	3.3E-07	4.2E-11	2.1E-09	7.1E-10	9.9E-12	6.5E-12	9.1E-14	6.6E-08	3.3E-06	1.1E-10	5.3E-09	7.0E-09	9.7E-11	1.6E-11	2.3E-13	3.5E-08	1.7E-06	1.4E-10	7.1E-09	3.7E-09	5.1E-11	2.2E-11	3.1E-13	4.9E-07	2.4E-05	9.4E-10	4.7E-08	5.2E-08	7.2E-10	1.5E-10	2.0E-12	

Table H-2. Site Exposure to Sediment via Dermal Contact, Hypothetical Recreational Fisher

Scenario Type: Baseline

Medium: Sediment

Exposure Pathway: Dermal Absorption

DAD<sub>factor, noncancer, RME</sub> = 6.64E-05

DAD<sub>factor, noncancer, CTE</sub> = 6.63E-06

DAD<sub>factor, cancer, RME</sub> = 1.98E-05

DAD<sub>factor, cancer, CTE</sub> = 1.02E-06

ADD = DAD<sub>sed, noncancer</sub> × C<sub>sed, d</sub> × ABS<sub>d</sub> × AF<sub>sed</sub> × SA × F<sub>sed</sub> × FI<sub>sed</sub> × EF<sub>sed</sub> × ED × EV × CF<sub>1</sub> / (BW × AT<sub>a</sub>)

LADD = DAD<sub>sed, cancer</sub> × C<sub>sed</sub> × ABS<sub>d</sub> × AF<sub>sed</sub> × SA × F<sub>sed</sub> × FI<sub>sed</sub> × EF<sub>sed</sub> × ED × EV × CF<sub>1</sub> / (BW × AT<sub>c</sub>)

HQ = ADD / RfD

Risk = LADD × CSF

DAD<sub>sed</sub> = C<sub>sed</sub> × ABS<sub>d</sub> × DAD<sub>factor</sub>

DAD<sub>factor</sub> = AF<sub>sed</sub> × SA × F<sub>sed</sub> × FI<sub>sed</sub> × EF<sub>sed</sub> × ED × EV × CF<sub>1</sub> / (BW × AT)

COPC <sub>H</sub>	Beach Area A								Beach Area B/C								Beach Area D								Beach Area E								
	Noncancer				Cancer				Noncancer				Cancer				Noncancer				Cancer				Noncancer				Cancer				
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	
Dioxins/Furans																																	
TEQ <sub>DF</sub> (ND = 1/2DL)	9.1E-13	1.3E-03	6.2E-14	8.8E-05	2.7E-13	3.9E-04	9.5E-15	2.7E-05	1.3E-11	1.8E-02	8.1E-13	1.2E-03	3.8E-12	5.5E-03	1.3E-13	3.5E-04	4.2E-12	6.0E-03	2.8E-13	4.0E-04	1.3E-12	1.8E-03	4.3E-14	1.2E-04	2.6E-08	3.7E+01	1.8E-10	2.6E-01	7.7E-09	1.1E+01	2.8E-11	7.9E-02	
TEQ <sub>DF</sub> (ND = DLO)	6.8E-13	9.6E-04	3.9E-14	5.6E-05	2.0E-13	2.9E-04	6.1E-15	1.7E-05	1.2E-11	1.7E-02	7.5E-13	1.1E-03	3.6E-12	5.3E-03	1.2E-13	3.3E-04	4.0E-12	5.7E-03	2.6E-13	3.7E-04	1.2E-12	1.7E-03	4.0E-14	1.1E-04	2.6E-08	3.7E+01	1.8E-10	2.5E-01	7.7E-09	1.1E+01	2.7E-11	7.6E-02	
Metals																																	
Arsenic (inorganic)	6.0E-07	2.0E-03	4.0E-08	1.3E-04	1.8E-07	2.7E-07	6.1E-09	9.2E-09	5.0E-06	1.7E-02	3.2E-07	1.1E-03	1.5E-06	2.2E-06	4.9E-08	7.3E-08	4.8E-06	1.6E-02	3.8E-07	1.3E-03	1.4E-06	2.2E-06	5.9E-08	8.9E-08	3.8E-06	1.3E-02	3.4E-07	1.1E-03	1.1E-06	1.7E-06	5.2E-08	7.8E-08	
Cadmium	6.6E-09	6.6E-06	6.6E-10	6.6E-07	2.0E-09	--	1.0E-10	--	1.4E-08	1.4E-05	5.4E-10	5.4E-07	4.2E-09	--	8.4E-11	--	2.9E-08	2.9E-05	2.2E-09	2.2E-06	8.5E-09	--	3.4E-10	--	1.1E-07	1.1E-04	2.0E-09	2.0E-06	3.2E-08	--	3.1E-10	--	
Chromium (III)	1.1E-06	7.3E-07	8.0E-08	5.3E-08	3.3E-07	--	1.2E-08	--	2.9E-05	1.9E-05	1.1E-06	7.2E-07	8.6E-06	--	1.7E-07	--	1.5E-05	1.0E-05	7.9E-07	5.3E-07	4.5E-06	--	1.2E-07	--	2.1E-05	1.4E-05	1.1E-06	7.1E-07	6.3E-06	--	1.6E-07	--	
Copper	2.3E-04	5.8E-03	5.4E-06	1.3E-04	6.9E-05	--	8.3E-07	--	4.6E-04	1.2E-02	3.8E-05	9.5E-04	1.4E-04	--	5.8E-06	--	5.2E-04	1.3E-02	3.9E-05	9.7E-04	1.6E-04	--	6.0E-06	--	3.8E-03	9.5E-02	1.1E-04	2.7E-03	1.1E-03	--	1.6E-05	--	
Mercury (inorganic)	2.1E-08	6.9E-05	1.2E-09	3.9E-06	6.2E-09	--	1.8E-10	--	4.0E-08	1.3E-04	2.0E-09	6.6E-06	1.2E-08	--	3.1E-10	--	8.0E-08	2.7E-04	4.0E-09	1.3E-05	2.4E-08	--	6.1E-10	--	4.0E-06	1.3E-02	4.0E-08	1.3E-04	1.2E-06	--	6.1E-09	--	
Nickel	1.0E-06	5.0E-05	8.4E-08	4.2E-06	3.0E-07	--	1.3E-08	--	2.3E-05	1.2E-03	1.4E-06	6.9E-05	7.0E-06	--	2.1E-07	--	1.7E-05	8.6E-04	1.4E-06	7.2E-05	5.2E-06	--	2.2E-07	--	2.5E-05	1.2E-03	1.9E-06	9.4E-05	7.4E-06	--	2.9E-07	--	
Zinc	5.7E-04	1.9E-03	2.2E-05	7.4E-05	1.7E-04	--	3.4E-06	--	3.2E-03	1.1E-02	1.6E-04	5.5E-04	9.5E-04	--	2.5E-05	--	3.0E-03	1.0E-02	2.0E-04	6.6E-04	9.1E-04	--	3.1E-05	--	1.5E-02	4.9E-02	4.3E-04	1.4E-03	4.4E-03	--	6.6E-05	--	
Polychlorinated Biphenyls																																	
Sum of Aroclors	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3E-05	6.5E-01	5.2E-07	2.6E-02	3.9E-06	7.8E-06	8.0E-08	8.0E-08
Sum of Aroclors (ND = DLO)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sum of 43 PCB Congeners (ND = 1/2DL)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Sum of 43 PCB Congeners (ND = DLO)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
TEQ <sub>B</sub> (ND = 1/2DL)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9.0E-12	1.3E-02	5.9E-13	8.5E-04	2.7E-12	3.9E-03	9.2E-14	2.6E-04
TEQ <sub>B</sub> (ND = DLO)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.7E-12	6.7E-03	3.2E-13	4.6E-04	1.4E-12	2.0E-03	4.9E-14	1.4E-04
Semivolatile Organic Compounds																																	
Bis(2-ethylhexyl)phthalate	6.3E-08	3.2E-06	6.3E-09	3.2E-07	1.9E-08	2.6E-10	9.7E-10	1.4E-11	6.2E-07	3.1E-05	1.6E-08	7.9E-07	1.9E-07	2.6E-09	2.4E-09	3.4E-11	3.3E-07	1.6E-05	2.1E-08	1.1E-06	9.8E-08	1.4E-09	3.3E-09	4.6E-11	4.6E-06	2.3E-04	1.4E-07	7.0E-06	1.4E-06	1.9E-08	2.2E-08	3.0E-10	

Table H-3. Site Exposure via Ingestion of Hardhead Catfish , Hypothetical Recreational Fisher

Scenario Type: Baseline

Medium: Hardhead Catfish Fillet

Exposure Pathway: Ingestion

$$ADD = I_{\text{tissue, noncancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_n)$$
$$LADD = I_{\text{tissue, cancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_c)$$
$$HQ = ADD / RfD$$
$$\text{Risk} = LADD \times CSF$$

$$I_{\text{factor, noncancer, RME}} = 1.87\text{E-}04$$
$$I_{\text{factor, noncancer, CTE}} = 2.66\text{E-}05$$
$$I_{\text{factor, cancer, RME}} = 4.21\text{E-}05$$
$$I_{\text{factor, cancer, CTE}} = 4.10\text{E-}06$$

$$I_{\text{tissue}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times I_{\text{factor}}$$
$$I_{\text{factor}} = IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT)$$

	FCA 1								FCA 2/3							
	Noncancer				Cancer				Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
COPC <sub>H</sub>																
Dioxins/Furans																
TEQ <sub>DF</sub> (ND = 1/2DL)	7.3E-10	1.0E+00	7.8E-11	1.1E-01	1.7E-10	3.2E-01	1.2E-11	3.4E-02	7.6E-10	1.1E+00	9.5E-11	1.4E-01	1.7E-10	3.3E-01	1.5E-11	4.1E-02
TEQ <sub>DF</sub> (ND = DL0)	7.2E-10	1.0E+00	7.7E-11	1.1E-01	1.6E-10	3.1E-01	1.2E-11	3.3E-02	7.5E-10	1.1E+00	9.3E-11	1.3E-01	1.7E-10	3.2E-01	1.4E-11	4.1E-02
Metals																
Arsenic (inorganic)	1.1E-05	3.5E-02	1.3E-06	4.3E-03	2.4E-06	3.6E-06	2.0E-07	3.0E-07	1.2E-05	4.1E-02	1.0E-06	3.5E-03	2.8E-06	4.2E-06	1.6E-07	2.4E-07
Arsenic (organic)	9.5E-05	9.5E-03	1.2E-05	1.2E-03	2.1E-05	--	1.8E-06	--	1.1E-04	1.1E-02	9.3E-06	9.3E-04	2.5E-05	--	1.4E-06	--
Cadmium	4.4E-07	4.4E-04	2.5E-08	2.5E-05	1.0E-07	--	3.8E-09	--	1.9E-07	1.9E-04	1.8E-08	1.8E-05	4.3E-08	--	2.8E-09	--
Chromium (III)	1.7E-05	1.2E-05	8.8E-07	5.9E-07	3.9E-06	--	1.4E-07	--	6.5E-06	4.3E-06	7.2E-07	4.8E-07	1.5E-06	--	1.1E-07	--
Copper	9.5E-05	2.4E-03	9.2E-06	2.3E-04	2.1E-05	--	1.4E-06	--	5.2E-05	1.3E-03	7.1E-06	1.8E-04	1.2E-05	--	1.1E-06	--
Mercury (methyl)	3.6E-05	3.6E-01	4.2E-06	4.2E-02	8.0E-06	--	6.5E-07	--	2.7E-05	2.7E-01	2.4E-06	2.4E-02	6.0E-06	--	3.7E-07	--
Nickel	1.1E-05	5.7E-04	7.2E-07	3.6E-05	2.6E-06	--	1.1E-07	--	6.0E-06	3.0E-04	5.0E-07	2.5E-05	1.3E-06	--	7.6E-08	--
Zinc	5.5E-03	1.8E-02	5.3E-04	1.8E-03	1.2E-03	--	8.1E-05	--	3.4E-03	1.1E-02	4.4E-04	1.5E-03	7.6E-04	--	6.7E-05	--
Polychlorinated Biphenyls																
Sum of Aroclors	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	1.9E-05	9.7E-01	2.3E-06	1.1E-01	4.4E-06	8.8E-06	3.5E-07	3.5E-07	1.8E-05	8.8E-01	2.2E-06	1.1E-01	4.0E-06	7.9E-06	3.4E-07	3.4E-07
Sum of 43 PCB Congeners (ND = DL0)	1.9E-05	9.7E-01	2.3E-06	1.1E-01	4.4E-06	8.8E-06	3.5E-07	3.5E-07	1.8E-05	8.8E-01	2.2E-06	1.1E-01	4.0E-06	7.9E-06	3.4E-07	3.4E-07
TEQ <sub>B</sub> (ND = 1/2DL)	3.1E-10	4.5E-01	3.7E-11	5.2E-02	7.0E-11	1.4E-01	5.7E-12	1.6E-02	2.9E-10	4.2E-01	3.5E-11	5.0E-02	6.6E-11	1.3E-01	5.4E-12	1.5E-02
TEQ <sub>B</sub> (ND = DL0)	2.7E-10	3.8E-01	2.8E-11	4.0E-02	6.0E-11	1.2E-01	4.3E-12	1.2E-02	4.4E-10	6.4E-01	1.9E-11	2.6E-02	1.0E-10	1.9E-01	2.9E-12	8.1E-03
Semivolatile Organic Compounds																
Bis(2-ethylhexyl)phthalate	2.0E-05	9.8E-04	2.8E-06	1.4E-04	4.4E-06	6.2E-08	4.3E-07	6.0E-09	2.0E-05	9.8E-04	2.8E-06	1.4E-04	4.4E-06	6.2E-08	4.3E-07	6.0E-09

Table H-4. Site Exposure via Ingestion of Clam, Hypothetical Recreational Fisher

Scenario Type: Baseline

Medium: Edible Clam Tissue

Exposure Pathway: Ingestion

$$ADD = I_{\text{tissue, noncancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_n)$$

$$LADD = I_{\text{tissue, cancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_c)$$

$$HQ = ADD / RfD$$

$$\text{Risk} = LADD \times CSF$$

$$I_{\text{factor, noncancer, RME}} = 7.89\text{E-}06$$

$$I_{\text{factor, noncancer, CTE}} = 1.25\text{E-}06$$

$$I_{\text{factor, cancer, RME}} = 2.18\text{E-}06$$

$$I_{\text{factor, cancer, CTE}} = 1.92\text{E-}07$$

$$I_{\text{tissue}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times I_{\text{factor}}$$

$$I_{\text{factor}} = IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT)$$

	FCA 1/3								FCA 2							
	Noncancer				Cancer				Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
COPC <sub>H</sub>																
Dioxins/Furans																
TEQ <sub>DF</sub> (ND = 1/2DL)	1.3E-11	1.9E-02	1.6E-12	2.3E-03	3.6E-12	5.7E-03	2.4E-13	6.9E-04	1.5E-10	2.1E-01	5.5E-12	7.9E-03	4.1E-11	6.5E-02	8.5E-13	2.4E-03
TEQ <sub>DF</sub> (ND = DL0)	1.2E-11	1.7E-02	1.4E-12	1.9E-03	3.3E-12	5.2E-03	2.1E-13	5.9E-04	1.7E-10	2.4E-01	4.9E-12	7.0E-03	4.7E-11	7.3E-02	7.5E-13	2.1E-03
Metals																
Arsenic (inorganic)	4.1E-07	1.4E-03	6.1E-08	2.0E-04	1.1E-07	1.7E-07	9.4E-09	1.4E-08	4.6E-07	1.5E-03	6.8E-08	2.3E-04	1.3E-07	1.9E-07	1.1E-08	1.6E-08
Arsenic (organic)	3.7E-06	3.7E-04	5.5E-07	5.5E-05	1.0E-06	--	8.5E-08	--	4.2E-06	4.2E-04	6.1E-07	6.1E-05	1.1E-06	--	9.5E-08	--
Cadmium	2.1E-07	2.1E-04	3.2E-08	3.2E-05	5.8E-08	--	4.9E-09	--	2.3E-07	2.3E-04	3.4E-08	3.4E-05	6.4E-08	--	5.3E-09	--
Chromium (III)	1.6E-06	1.1E-06	2.1E-07	1.4E-07	4.4E-07	--	3.3E-08	--	1.7E-06	1.2E-06	2.0E-07	1.3E-07	4.8E-07	--	3.1E-08	--
Copper	2.7E-05	6.7E-04	2.9E-06	7.2E-05	7.3E-06	--	4.4E-07	--	3.2E-05	7.9E-04	3.3E-06	8.2E-05	8.8E-06	--	5.1E-07	--
Mercury (methyl)	1.0E-07	1.0E-03	1.4E-08	1.4E-04	2.8E-08	--	2.1E-09	--	9.0E-08	9.0E-04	1.2E-08	1.2E-04	2.5E-08	--	1.8E-09	--
Nickel	1.2E-05	6.2E-04	1.7E-06	8.7E-05	3.4E-06	--	2.7E-07	--	1.0E-05	5.1E-04	1.5E-06	7.4E-05	2.8E-06	--	2.3E-07	--
Zinc	8.4E-05	2.8E-04	1.2E-05	4.1E-05	2.3E-05	--	1.9E-06	--	9.0E-05	3.0E-04	1.4E-05	4.5E-05	2.5E-05	--	2.1E-06	--
Polychlorinated Biphenyls																
Sum of Aroclors	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	1.7E-07	8.6E-03	2.4E-08	1.2E-03	4.7E-08	9.5E-08	3.7E-09	3.7E-09	3.9E-07	2.0E-02	3.3E-08	1.6E-03	1.1E-07	2.2E-07	5.0E-09	5.0E-09
Sum of 43 PCB Congeners (ND = DL0)	1.7E-07	8.5E-03	2.4E-08	1.2E-03	4.7E-08	9.4E-08	3.7E-09	3.7E-09	3.9E-07	2.0E-02	3.3E-08	1.6E-03	1.1E-07	2.2E-07	5.0E-09	5.0E-09
TEQ <sub>B</sub> (ND = 1/2DL)	2.7E-12	3.9E-03	3.7E-13	5.2E-04	7.5E-13	1.2E-03	5.6E-14	1.6E-04	6.5E-12	9.3E-03	5.1E-13	7.3E-04	1.8E-12	2.8E-03	7.9E-14	2.2E-04
TEQ <sub>B</sub> (ND = DL0)	6.3E-13	9.0E-04	8.3E-14	1.2E-04	1.7E-13	2.8E-04	1.3E-14	3.6E-05	3.5E-12	5.0E-03	1.8E-13	2.5E-04	9.6E-13	1.5E-03	2.7E-14	7.7E-05
Semivolatile Organic Compounds																
Bis(2-ethylhexyl)phthalate	8.3E-07	4.1E-05	1.3E-07	6.6E-06	2.3E-07	3.2E-09	2.0E-08	2.8E-10	8.3E-07	4.1E-05	1.3E-07	6.6E-06	2.3E-07	3.2E-09	2.0E-08	2.8E-10

Table H-5. Site Exposure via Ingestion of Crab, Hypothetical Recreational Fisher

Scenario Type: Baseline

Medium: Edible Crab Tissue

Exposure Pathway: Ingestion

$$ADD = I_{\text{tissue, noncancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_n)$$

$$LADD = I_{\text{tissue, cancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_c)$$

$$HQ = ADD / RfD$$

$$\text{Risk} = LADD \times CSF$$

$$I_{\text{factor, noncancer, RME}} = 7.89\text{E-}06$$

$$I_{\text{factor, noncancer, CTE}} = 1.25\text{E-}06$$

$$I_{\text{factor, cancer, RME}} = 2.18\text{E-}06$$

$$I_{\text{factor, cancer, CTE}} = 1.92\text{E-}07$$

$$I_{\text{tissue}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1 - \text{LOSS}) \times I_{\text{factor}}$$

$$I_{\text{factor}} = IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT)$$

	FCA 1								FCA 2/3							
	Noncancer				Cancer				Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)		RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
COPC <sub>H</sub>																
Dioxins/Furans																
TEQ <sub>DF</sub> (ND = 1/2DL)	8.4E-12	1.2E-02	9.2E-13	1.3E-03	2.3E-12	3.7E-03	1.4E-13	4.0E-04	2.3E-12	3.2E-03	2.1E-13	2.9E-04	6.2E-13	9.8E-04	3.2E-14	8.9E-05
TEQ <sub>DF</sub> (ND = DL0)	7.7E-12	1.1E-02	7.5E-13	1.1E-03	2.1E-12	3.3E-03	1.2E-13	3.3E-04	1.4E-12	2.0E-03	7.7E-14	1.1E-04	3.8E-13	6.0E-04	1.2E-14	3.4E-05
Metals																
Arsenic (inorganic)	4.1E-07	1.4E-03	5.8E-08	1.9E-04	1.1E-07	1.7E-07	9.0E-09	1.3E-08	3.6E-07	1.2E-03	5.3E-08	1.8E-04	1.0E-07	1.5E-07	8.2E-09	1.2E-08
Arsenic (organic)	3.7E-06	3.7E-04	5.2E-07	5.2E-05	1.0E-06	--	8.1E-08	--	3.3E-06	3.3E-04	4.8E-07	4.8E-05	9.0E-07	--	7.4E-08	--
Cadmium	1.9E-07	1.9E-04	1.9E-08	1.9E-05	5.3E-08	--	2.8E-09	--	1.6E-07	1.6E-04	1.3E-08	1.3E-05	4.4E-08	--	2.0E-09	--
Chromium (III)	5.0E-07	3.3E-07	5.9E-08	3.9E-08	1.4E-07	--	9.0E-09	--	2.1E-07	1.4E-07	1.2E-08	8.2E-09	5.7E-08	--	1.9E-09	--
Copper	1.1E-04	2.7E-03	1.4E-05	3.5E-04	3.0E-05	--	2.1E-06	--	8.8E-05	2.2E-03	1.3E-05	3.3E-04	2.4E-05	--	2.0E-06	--
Mercury (methyl)	4.6E-07	4.6E-03	6.6E-08	6.6E-04	1.3E-07	--	1.0E-08	--	3.0E-07	3.0E-03	4.2E-08	4.2E-04	8.3E-08	--	6.5E-09	--
Nickel	4.3E-07	2.1E-05	5.3E-08	2.6E-06	1.2E-07	--	8.1E-09	--	5.3E-07	2.7E-05	4.4E-08	2.2E-06	1.5E-07	--	6.7E-09	--
Zinc	4.1E-04	1.4E-03	6.3E-05	2.1E-04	1.1E-04	--	9.7E-06	--	3.9E-04	1.3E-03	6.0E-05	2.0E-04	1.1E-04	--	9.2E-06	--
Polychlorinated Biphenyls																
Sum of Aroclors	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	2.6E-08	1.3E-03	1.5E-09	7.3E-05	7.3E-09	1.5E-08	2.2E-10	2.2E-10	5.7E-08	2.8E-03	5.9E-09	2.9E-04	1.6E-08	3.1E-08	9.1E-10	9.1E-10
Sum of 43 PCB Congeners (ND = DL0)	2.6E-08	1.3E-03	1.4E-09	6.8E-05	7.2E-09	1.4E-08	2.1E-10	2.1E-10	5.6E-08	2.8E-03	5.8E-09	2.9E-04	1.6E-08	3.1E-08	9.0E-10	9.0E-10
TEQ <sub>B</sub> (ND = 1/2DL)	1.2E-12	1.7E-03	1.5E-13	2.1E-04	3.2E-13	5.1E-04	2.3E-14	6.5E-05	2.3E-12	3.3E-03	2.1E-13	2.9E-04	6.4E-13	1.0E-03	3.2E-14	9.0E-05
TEQ <sub>B</sub> (ND = DL0)	1.6E-13	2.3E-04	8.1E-15	1.2E-05	4.4E-14	6.9E-05	1.2E-15	3.5E-06	1.5E-12	2.1E-03	8.3E-14	1.2E-04	4.1E-13	6.4E-04	1.3E-14	3.6E-05
Semivolatile Organic Compounds																
Bis(2-ethylhexyl)phthalate	8.3E-07	4.1E-05	1.3E-07	6.6E-06	2.3E-07	3.2E-09	2.0E-08	2.8E-10	8.3E-07	4.1E-05	1.3E-07	6.6E-06	2.3E-07	3.2E-09	2.0E-08	2.8E-10

Notes

- = not applicable
- ADD = average daily dose
- CF<sub>1</sub> = conversion factor 1; 1E-06 kg/mg
- CF<sub>2</sub> = conversion factor 2; 1E-03 kg/g
- COPC<sub>H</sub> = chemical of potential concern for human health
- CTE = central tendency exposure
- FCA = fish collection area
- HQ = hazard quotient
- LADD = lifetime average daily dose
- ND = 1/2DL = nondetects set at one-half the detection limit
- ND = DL0 = nondetects set at zero.
- TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans
- TEQ<sub>B</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls
- a - Cancer "risks" from exposure to TEQ<sub>DF</sub> and TEQ<sub>B</sub> are actually carcinogenic hazards, calculated using a cancer-based TCDD TDI and ADDs that incorporate exposure parameters for the young child (RME) and adult (CTE).

Hypothetical Recreational Fisher: Exposure Pathway-Specific Noncancer Hazards and Cancer Risks, Background

Table I-1. Background Exposure to Sediment via Incidental Ingestion, Hypothetical Recreational Fisher

Scenario Type: Background	$ADD = I_{sed, noncancer} = C_{sed} \times RBA_{sed} \times IR_{sed} \times F_{sed} \times FI_{sed} \times EF_{sed} \times ED \times CF_1 / (BW \times AT_n)$
Medium: Sediment	$LADD = I_{sed, cancer} = C_{sed} \times RBA_{sed} \times IR_{sed} \times F_{sed} \times FI_{sed} \times EF_{sed} \times ED \times CF_1 / (BW \times AT_c)$
Exposure Pathway: Incidental Ingestion	$HQ = ADD / RfD$
	$Risk = LADD \times CSF$
	$I_{sed} = C_{sed} \times RBA_{sed} \times I_{factor}$
$I_{factor, noncancer, RME} = 7.03E-07$	$I_{factor} = IR_{sed} \times F_{sed} \times FI_{sed} \times EF_{sed} \times ED \times CF_1 / (BW \times AT)$
$I_{factor, noncancer, CTE} = 4.45E-09$	
$I_{factor, cancer, RME} = 7.46E-08$	
$I_{factor, cancer, CTE} = 6.85E-10$	

COPC <sub>H</sub>	Background Sediment							
	Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
Dioxins/Furans								
TEQ <sub>DF</sub> (ND = 1/2DL)	2.1E-13	3.0E-04	8.9E-16	1.3E-06	2.3E-14	9.3E-05	1.4E-16	3.9E-07
TEQ <sub>DF</sub> (ND = DLO)	1.8E-13	2.6E-04	6.7E-16	9.6E-07	1.9E-14	7.8E-05	1.0E-16	2.9E-07
Metals								
Arsenic (inorganic)	3.4E-07	1.1E-03	9.0E-10	3.0E-06	3.6E-08	5.4E-08	1.4E-10	2.1E-10
Cadmium	1.2E-07	1.2E-04	4.0E-10	4.0E-07	1.3E-08	--	6.2E-11	--
Chromium (III)	3.4E-06	2.3E-06	8.1E-09	5.4E-09	3.6E-07	--	1.2E-09	--
Copper	1.4E-06	3.4E-05	6.1E-09	1.5E-07	1.4E-07	--	9.3E-10	--
Mercury (inorganic)	3.2E-09	1.1E-05	1.2E-11	4.0E-08	3.4E-10	--	1.9E-12	--
Nickel	2.8E-06	1.4E-04	4.0E-09	2.0E-07	2.9E-07	--	6.2E-10	--
Zinc	7.2E-06	2.4E-05	1.9E-08	6.4E-08	7.7E-07	--	3.0E-09	--
Polychlorinated Biphenyls								
Sum of Aroclors	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DLO)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = DLO)	--	--	--	--	--	--	--	--
TEQ <sub>P</sub> (ND = 1/2DL)	7.0E-14	9.9E-05	3.7E-16	5.2E-07	7.4E-15	3.0E-05	5.7E-17	1.6E-07
TEQ <sub>P</sub> (ND = DLO)	3.5E-15	5.0E-06	1.1E-17	1.6E-08	3.7E-16	1.5E-06	1.7E-18	4.8E-09
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	1.2E-08	5.8E-07	4.8E-11	2.4E-09	1.2E-09	1.7E-11	7.4E-12	1.0E-13

Table I-2. Background Exposure to Sediment via Dermal Contact, Hypothetical Recreational Fisher

Scenario Type: Background

Medium: Sediment

Exposure Pathway: Dermal Contact

$$ADD = DAD_{sed, noncancer} = C_{sed} \times ABS_d \times AF_{sed} \times SA \times F_{sed} \times FI_{sed} \times EF_{sed} \times ED \times EV \times CF_1 / (BW \times AT_n)$$
$$LADD = DAD_{sed, cancer} = C_{sed} \times ABS_d \times AF_{sed} \times SA \times F_{sed} \times FI_{sed} \times EF_{sed} \times ED \times EV \times CF_1 / (BW \times AT_c)$$
$$HQ = ADD / RfD$$
$$Risk = LADD \times CSF$$

$$DAD_{factor, noncancer, RME} = 6.64E-05$$
$$DAD_{factor, noncancer, CTE} = 6.63E-06$$
$$DAD_{factor, cancer, RME} = 1.98E-05$$
$$DAD_{factor, cancer, CTE} = 1.02E-06$$

$$DAD_{sed} = C_{sed} \times ABS_d \times DAD_{factor}$$
$$DAD_{factor} = AF_{sed} \times SA \times F_{sed} \times FI_{sed} \times EF_{sed} \times ED \times EV \times CF_1 / (BW \times AT)$$

COPC <sub>H</sub>	Background Sediment							
	Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
Dioxins/Furans								
TEQ <sub>DF</sub> (ND = 1/2DL)	1.2E-12	1.7E-03	8.0E-14	1.1E-04	3.6E-13	5.3E-04	1.2E-14	3.5E-05
TEQ <sub>DF</sub> (ND = DL0)	1.0E-12	1.5E-03	6.0E-14	8.6E-05	3.1E-13	4.4E-04	9.2E-15	2.6E-05
Metals								
Arsenic (inorganic)	1.9E-06	6.4E-03	8.0E-08	2.7E-04	5.8E-07	8.6E-07	1.2E-08	1.9E-08
Cadmium	1.2E-08	1.2E-05	6.0E-10	6.0E-07	3.5E-09	--	9.3E-11	--
Chromium (III)	6.4E-06	4.3E-06	2.4E-07	1.6E-07	1.9E-06	--	3.7E-08	--
Copper	1.3E-04	3.2E-03	9.0E-06	2.3E-04	3.8E-05	--	1.4E-06	--
Mercury (inorganic)	9.0E-09	3.0E-05	5.4E-10	1.8E-06	2.7E-09	--	8.3E-11	--
Nickel	1.0E-05	5.2E-04	2.4E-07	1.2E-05	3.1E-06	--	3.7E-08	--
Zinc	6.8E-04	2.3E-03	2.9E-05	9.5E-05	2.0E-04	--	4.4E-06	--
Polychlorinated Biphenyls								
Sum of Aroclors	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = DL0)	--	--	--	--	--	--	--	--
TEQ <sub>p</sub> (ND = 1/2DL)	3.9E-13	5.6E-04	3.3E-14	4.7E-05	1.2E-13	1.7E-04	5.1E-15	1.4E-05
TEQ <sub>p</sub> (ND = DL0)	2.0E-14	2.8E-05	9.9E-16	1.4E-06	5.9E-15	8.7E-06	1.5E-16	4.3E-07
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	1.1E-07	5.5E-06	7.2E-09	3.6E-07	3.3E-08	4.6E-10	1.1E-09	1.5E-11

Table I-3. Background Exposure via Ingestion of Hardhead Catfish Fillet, Hypothetical Recreational Fisher

Scenario Type: Background

Medium: Hardhead Catfish Fillet

Exposure Pathway: Ingestion

$$ADD = I_{\text{tissue, noncancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_n)$$

$$LADD = I_{\text{tissue, cancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_c)$$

$$HQ = ADD / RfD$$

$$Risk = LADD \times CSF$$

$$I_{\text{factor, noncancer, RME}} = 1.87\text{E-}04$$

$$I_{\text{factor, noncancer, CTE}} = 2.66\text{E-}05$$

$$I_{\text{factor, cancer, RME}} = 4.21\text{E-}05$$

$$I_{\text{factor, cancer, CTE}} = 4.10\text{E-}06$$

$$I_{\text{tissue}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times I_{\text{factor}}$$

$$I_{\text{factor}} = IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT)$$

	Background Catfish							
	Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
COPC <sub>H</sub>								
Dioxins/Furans								
TEQ <sub>DF</sub> (ND = 1/2DL)	3.1E-10	4.4E-01	1.3E-11	1.8E-02	6.9E-11	1.3E-01	1.9E-12	5.5E-03
TEQ <sub>DF</sub> (ND = DL0)	8.3E-10	1.2E+00	3.2E-12	4.6E-03	1.9E-10	3.6E-01	5.0E-13	1.4E-03
Metals								
Arsenic (inorganic)	6.3E-06	2.1E-02	7.7E-07	2.6E-03	1.4E-06	2.1E-06	1.2E-07	1.8E-07
Arsenic (organic)	5.7E-05	5.7E-03	6.9E-06	6.9E-04	1.3E-05	--	1.1E-06	--
Cadmium	4.2E-07	4.2E-04	2.3E-08	2.3E-05	9.4E-08	--	3.6E-09	--
Chromium (III)	5.6E-06	3.7E-06	3.7E-07	2.5E-07	1.3E-06	--	5.7E-08	--
Copper	3.3E-04	8.3E-03	1.6E-05	4.1E-04	7.5E-05	--	2.5E-06	--
Mercury (methyl)	2.8E-05	2.8E-01	3.4E-06	3.4E-02	6.3E-06	--	5.2E-07	--
Nickel	4.1E-06	2.0E-04	3.1E-07	1.5E-05	9.2E-07	--	4.8E-08	--
Zinc	3.0E-03	9.9E-03	3.7E-04	1.2E-03	6.7E-04	--	5.7E-05	--
Polychlorinated Biphenyls								
Sum of Aroclors	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	1.1E-05	5.3E-01	1.3E-06	6.4E-02	2.4E-06	4.8E-06	2.0E-07	2.0E-07
Sum of 43 PCB Congeners (ND = DL0)	1.1E-05	5.3E-01	1.3E-06	6.4E-02	2.4E-06	4.8E-06	2.0E-07	2.0E-07
TEQ <sub>P</sub> (ND = 1/2DL)	3.1E-10	4.4E-01	2.6E-11	3.7E-02	6.9E-11	1.3E-01	4.0E-12	1.1E-02
TEQ <sub>P</sub> (ND = DL0)	1.4E-10	2.0E-01	7.8E-12	1.1E-02	3.2E-11	6.1E-02	1.2E-12	3.4E-03
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	2.0E-05	9.8E-04	2.8E-06	1.4E-04	4.4E-06	6.2E-08	4.3E-07	6.0E-09

Table I-4. Background Exposure via Ingestion of Clam, Hypothetical Recreational Fisher

Scenario Type: Background	$ADD = I_{\text{tissue, noncancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_n)$
Medium: Edible Clam Tissue	$LADD = I_{\text{tissue, cancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_c)$
Exposure Pathway: Ingestion	HQ = ADD / RfD
	Risk = LADD x CSF
	$I_{\text{tissue}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times I_{\text{factor}}$
$I_{\text{factor, noncancer, RME}} = 7.89\text{E-}06$	$I_{\text{factor}} = IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT)$
$I_{\text{factor, noncancer, CTE}} = 1.25\text{E-}06$	
$I_{\text{factor, cancer, RME}} = 2.18\text{E-}06$	
$I_{\text{factor, cancer, CTE}} = 1.92\text{E-}07$	

COPC <sub>H</sub>	Background Clam							
	Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
Dioxins/Furans								
TEQ <sub>DF</sub> (ND = 1/2DL)	3.7E-12	5.3E-03	4.6E-13	6.5E-04	1.0E-12	1.6E-03	7.0E-14	2.0E-04
TEQ <sub>DF</sub> (ND = DL0)	3.1E-12	4.5E-03	1.7E-13	2.5E-04	8.6E-13	1.4E-03	2.7E-14	7.6E-05
Metals								
Arsenic (inorganic)	4.2E-07	1.4E-03	6.1E-08	2.0E-04	1.1E-07	1.7E-07	9.4E-09	1.4E-08
Arsenic (organic)	3.8E-06	3.8E-04	5.5E-07	5.5E-05	1.0E-06	--	8.5E-08	--
Cadmium	1.1E-07	1.1E-04	1.6E-08	1.6E-05	3.0E-08	--	2.4E-09	--
Chromium (III)	1.2E-06	7.7E-07	1.6E-07	1.1E-07	3.2E-07	--	2.5E-08	--
Copper	1.3E-05	3.2E-04	1.8E-06	4.6E-05	3.5E-06	--	2.8E-07	--
Mercury (methyl)	5.3E-08	5.3E-04	7.7E-09	7.7E-05	1.5E-08	--	1.2E-09	--
Nickel	1.1E-05	5.5E-04	1.5E-06	7.5E-05	3.0E-06	--	2.3E-07	--
Zinc	8.3E-05	2.8E-04	1.2E-05	4.1E-05	2.3E-05	--	1.9E-06	--
Polychlorinated Biphenyls								
Sum of Aroclors	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	9.4E-08	4.7E-03	1.0E-08	5.2E-04	2.6E-08	5.2E-08	1.6E-09	1.6E-09
Sum of 43 PCB Congeners (ND = DL0)	9.2E-08	4.6E-03	1.0E-08	5.0E-04	2.5E-08	5.1E-08	1.5E-09	1.5E-09
TEQ <sub>P</sub> (ND = 1/2DL)	1.7E-12	2.4E-03	2.3E-13	3.2E-04	4.6E-13	7.3E-04	3.5E-14	9.8E-05
TEQ <sub>P</sub> (ND = DL0)	3.0E-13	4.3E-04	2.8E-14	4.0E-05	8.4E-14	1.3E-04	4.3E-15	1.2E-05
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	8.3E-07	4.1E-05	1.3E-07	6.6E-06	2.3E-07	3.2E-09	2.0E-08	2.8E-10

Table I-5. Background Exposure via Ingestion of Crab, Hypothetical Recreational Fisher

Scenario Type: Background	$ADD = I_{\text{tissue, noncancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_n)$
Medium: Edible Crab Tissue	$LADD = I_{\text{tissue, cancer}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT_c)$
Exposure Pathway: Ingestion	HQ = ADD / RfD Risk = LADD x CSF
	$I_{\text{tissue}} = C_{\text{tissue}} \times RBA_{\text{tissue}} \times (1-LOSS) \times I_{\text{factor}}$
$I_{\text{factor, noncancer, RME}} = 7.89\text{E-}06$	$I_{\text{factor}} = IR_{\text{tissue}} \times FI_{\text{tissue}} \times EF_{\text{tissue}} \times ED \times CF_2 / (BW \times AT)$
$I_{\text{factor, noncancer, CTE}} = 1.25\text{E-}06$	
$I_{\text{factor, cancer, RME}} = 2.18\text{E-}06$	
$I_{\text{factor, cancer, CTE}} = 1.92\text{E-}07$	

	Background Crab							
	Noncancer				Cancer			
	RME (young child)		CTE (adult)		RME (lifetime)		CTE (adult)	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
COPC <sub>H</sub>								
Dioxins and Furans								
TEQ <sub>DF</sub> (ND = 1/2DL)	1.4E-12	2.1E-03	1.6E-13	2.3E-04	4.0E-13	6.3E-04	2.4E-14	6.8E-05
TEQ <sub>DF</sub> (ND = DL0)	7.3E-13	1.0E-03	3.7E-14	5.3E-05	2.0E-13	3.2E-04	5.8E-15	1.6E-05
Metals								
Arsenic (inorganic)	7.5E-07	2.5E-03	8.0E-08	2.7E-04	2.1E-07	3.1E-07	1.2E-08	1.8E-08
Arsenic (organic)	6.8E-06	6.8E-04	7.2E-07	7.2E-05	1.9E-06	--	1.1E-07	--
Cadmium	7.4E-08	7.4E-05	6.8E-09	6.8E-06	2.0E-08	--	1.0E-09	--
Chromium (III)	2.2E-07	1.4E-07	2.7E-08	1.8E-08	5.9E-08	--	4.1E-09	--
Copper	6.0E-05	1.5E-03	9.2E-06	2.3E-04	1.7E-05	--	1.4E-06	--
Mercury (methyl)	1.8E-07	1.8E-03	2.3E-08	2.3E-04	5.0E-08	--	3.6E-09	--
Nickel	3.7E-07	1.8E-05	4.8E-08	2.4E-06	1.0E-07	--	7.4E-09	--
Zinc	3.7E-04	1.2E-03	5.6E-05	1.9E-04	1.0E-04	--	8.7E-06	--
Polychlorinated Biphenyls								
Sum of Aroclors	--	--	--	--	--	--	--	--
Sum of Aroclors (ND = DL0)	--	--	--	--	--	--	--	--
Sum of 43 PCB Congeners (ND = 1/2DL)	8.3E-09	4.1E-04	1.1E-09	5.7E-05	2.3E-09	4.6E-09	1.8E-10	1.8E-10
Sum of 43 PCB Congeners (ND = DL0)	7.6E-09	3.8E-04	1.0E-09	5.2E-05	2.1E-09	4.2E-09	1.6E-10	1.6E-10
TEQ <sub>P</sub> (ND = 1/2DL)	7.5E-13	1.1E-03	1.0E-13	1.5E-04	2.1E-13	3.2E-04	1.6E-14	4.5E-05
TEQ <sub>P</sub> (ND = DL0)	4.1E-14	5.8E-05	5.3E-15	7.6E-06	1.1E-14	1.8E-05	8.1E-16	2.3E-06
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	8.3E-07	4.1E-05	1.3E-07	6.6E-06	2.3E-07	3.2E-09	2.0E-08	2.8E-10

**Notes**

-- = not applicable

ADD = average daily dose

COPC<sub>H</sub> = chemical of potential concern for human health

CTE = central tendency exposure

HQ = hazard quotient

LADD = lifetime average daily dose

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DL0 = nondetects set at zero

RME = reasonable maximum exposure

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

TEQ<sub>P</sub> = toxicity equivalent for dioxin-like polychlorinated biphenyls

a - Cancer "risks" from exposure to TEQ<sub>DF</sub> and TEQ<sub>P</sub> are presented as cancer hazards, calculated using a cancer-based TCDD TDI and ADDs that incorporate exposure parameters for the young child (RME) and adult (CTE).

## Hypothetical Trespasser: Exposure Pathway-Specific Noncancer Hazards, Cancer Risks, and Dioxin Cancer Hazards, Area of Investigation on the Peninsula South of I-10

**Table J-1. Site Exposure to Soil via Incidental Ingestion, Hypothetical Trespasser**

**Scenario:** Baseline

**Medium:** Surface soils

**Exposure Pathway:** Incidental ingestion

$$ADD = I_{\text{soil, noncancer}} = C_{\text{soil}} \times RBA_{\text{soil}} \times IR_{\text{soil}} \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times CF_1 / (BW \times AT_n)$$

$$LADD = I_{\text{soil, cancer}} = C_{\text{soil}} \times RBA_{\text{soil}} \times IR_{\text{soil}} \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times CF_1 / (BW \times AT_c)$$

$$\text{Noncancer HQ} = ADD / RfD$$

$$\text{Cancer Hazard (for TEQdf only)} = ADD / TDI$$

$$\text{Cancer Risk} = LADD \times CSF$$

$$I_{\text{factor, noncancer, RME}} = 1.82\text{E-}08$$

$$I_{\text{factor, noncancer, CTE}} = 4.55\text{E-}09$$

$$I_{\text{factor, cancer, RME}} = 1.63\text{E-}09$$

$$I_{\text{factor, cancer, CTE}} = 2.34\text{E-}10$$

$$I_{\text{soil}} = C_{\text{soil}} \times RBA_{\text{soil}} \times I_{\text{factor}}$$

$$I_{\text{factor}} = IR_{\text{soil}} \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times CF_1 / (BW \times AT)$$

COPC <sub>H</sub>	Area of Investigation on the Peninsula South of I-10							
	Noncancer				Cancer			
	RME		CTE		RME		CTE	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	DRAFT	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
<b>Dioxins and Furans</b>								
TEQ <sub>DF</sub> (ND=1/2DL)	2.5E-13	3.6E-04	2.3E-14	3.4E-05	2.3E-14	1.1E-04	1.2E-15	1.0E-05
TEQ <sub>DF</sub> (ND=DL0)	2.6E-13	3.7E-04	2.3E-14	3.3E-05	2.3E-14	1.1E-04	1.2E-15	9.9E-06
<b>Metals</b>								
Arsenic <sup>b</sup>	1.0E-06	3.3E-03	7.1E-08	2.4E-04	9.0E-08	1.3E-07	3.6E-09	5.4E-09
<b>Semivolatile Organic Compounds</b>								
Benzo(a)pyrene	6.7E-09	--	6.4E-10	--	6.0E-10	4.4E-09	3.3E-11	2.4E-10

**Table J-2. Site Exposure to Soil via Dermal Contact, Hypothetical Trespasser**

**Scenario:** Baseline

**Medium:** Surface soils

**Exposure Pathway:** Dermal contact

$$ADD = DAD_{\text{soil, noncancer}} = C_{\text{soil}} \times ABS_d \times AF_{\text{soil}} \times SA \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times EV \times CF_1 / (BW \times AT_n)$$

$$LADD = DAD_{\text{soil, cancer}} = C_{\text{soil}} \times ABS_d \times AF_{\text{soil}} \times SA \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times EV \times CF_1 / (BW \times AT_c)$$

$$\text{Noncancer HQ} = ADD / RfD$$

$$\text{Cancer Hazard (for TEQdf only)} = ADD / TDI$$

$$\text{Cancer Risk} = LADD \times CSF$$

$$DAD_{\text{factor, noncancer, RME}} = 1.71\text{E-}07$$

$$DAD_{\text{factor, noncancer, CTE}} = 4.28\text{E-}08$$

$$DAD_{\text{factor, cancer, RME}} = 1.54\text{E-}08$$

$$DAD_{\text{factor, cancer, CTE}} = 2.19\text{E-}09$$

$$DAD_{\text{soil}} = C_{\text{soil}} \times ABS_d \times DAD_{\text{factor}}$$

$$DAD_{\text{factor}} = AF_{\text{soil}} \times SA \times FI_{\text{soil}} \times EF_{\text{soil}} \times ED \times EV \times CF_1 / (BW \times AT)$$

COPC <sub>H</sub>	Area of Investigation on the Peninsula South of I-10							
	Noncancer				Cancer			
	RME		CTE		RME		CTE	
	ADD (mg/kg-day)	HQ (unitless)	ADD (mg/kg-day)	HQ (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)	LADD (mg/kg-day)	Risk <sup>a</sup> (unitless)
<b>Dioxins and Furans</b>								
TEQ <sub>DF</sub> (ND=1/2DL)	1.4E-13	2.0E-04	1.3E-14	1.9E-05	1.3E-14	6.2E-05	6.8E-16	5.7E-06
TEQ <sub>DF</sub> (ND=DLO)	1.4E-13	2.1E-04	1.3E-14	1.8E-05	1.3E-14	6.3E-05	6.6E-16	5.6E-06
<b>Metals</b>								
Arsenic <sup>b</sup>	5.6E-07	1.9E-03	4.0E-08	1.3E-04	5.1E-08	7.6E-08	2.0E-09	3.1E-09
<b>Semivolatile Organic Compounds</b>								
Benzo(a)pyrene	8.2E-09	--	7.8E-10	--	7.3E-10	5.4E-09	4.0E-11	2.9E-10

#### Notes

-- = not applicable

ADD = average daily dose

CF<sub>1</sub> = conversion factor 1; 1E-06 kg/mg

COPC<sub>H</sub> = chemical of potential concern for human health

CTE = central tendency exposure

HQ = hazard quotient

LADD = lifetime average daily dose

ND = 1/2DL = nondetects set at one-half the detection limit

ND = DLO = Nondetects set at zero.

TEQ<sub>DF</sub> = toxicity equivalent for dioxins and furans

a - Cancer "risks" from exposure to TEQ<sub>DF</sub> are actually carcinogenic hazards, calculated using a cancer-based TCDD TDI and ADDs that incorporate exposure parameters for the young child (RME) and adult (CTE).

b - Arsenic is assumed to be present in its inorganic form.